THE FABRIC OF MODERN BUILDINGS

WARLAND

A. J. Perry.

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BY

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PREFACE

The subject of Building Construction has been approached from many angles. Although it is so well covered by textbooks and the technical press, there appears to be a demand for a book dealing with the constructional problems of modern buildings. In recent years I have had the pleasure of visiting many of the large buildings throughout the country during the process of their erection.

This intimate acquaintance has enabled me to appreciate the changes which have taken place in methods of building construction. These methods are dynamic; what is considered to be modern to-day will be supplanted to-morrow. This development is largely the result of scientific research and the production of new types of building material, the use of structural steelwork, and reinforced concrete.

The traditional method of building construction is the fundamental basis upon which all modern structures are erected. Therefore it is essential to obtain a complete knowledge of the principles before attempting a study of modern methods.

It is unfair to condemn new methods of construction just because they are new. It must be remembered that new materials necessitate new methods for their proper application as structural or decorative units. Brick and stone are undoubtedly the most reliable materials for the fabric of a building. They have a history, and their use as building materials does not involve any great risk in regard to their behaviour over a long period. For these reasons alone they will continue to be used as walling materials especially for buildings of national and civic importance.

There is no reason why brick or stone should be supplanted by new materials, but it is necessary that the method of using these materials should conform to the requirements of modern framed structures.

The entire loads of such structures should be carried by the framework.

Therefore the lighter the walls, floors, etc., the lighter will be the load to be carried by the framework. It is because of this that changed methods of wall construction are necessary, and the traditional idea that mass and thickness implies strength and durability should not apply to walls intended as the clothing to modern framed structures. The insulation of walls from the vagaries of climatic conditions and air-borne noises appears to be of more importance than thickness.

If this view of the matter is accepted—and there are unmistakable signs that it is being regarded as the attitude to adopt—it should follow that instruction

in the modern methods must form an important part of the building construction courses in the technical colleges throughout the country.

This book deals chiefly with the fabric of buildings and the construction necessary for housing the mechanical equipment. The installation of mechanical heating and ventilating systems has caused many changes in the construction of walls, floors, ceilings, etc. The effective concealment of trunking systems and ducts has been made possible very largely by the introduction of framed structures.

Fibrous plaster has been looked upon as a cheap form of plaster finish for the walls, ceilings, and internal decorative treatment, and as such it has always been relegated to the internal enrichment of buildings of minor importance. The provision of spaces for housing the various service conduits and ducts has necessitated the more general use of fibrous plaster, even in buildings of national importance.

Because interior decorative design is very largely regulated by the necessity for effectively covering ventilation ducts and heating systems, it is requisite that the designer should understand the structural requirements of the framework for the decoration as well as the decorative expression.

Many readers will recognize some of the diagrams in this book because they have appeared from time to time in *Building* under the initials of E.G.W. My thanks are due to its Editor, Mr. R. Greenhalgh, for allowing me to incorporate in this book some of the diagrams which I have contributed to that journal. The success of the illustrations in *Building* has encouraged me to continue the isometric illustrations of constructional items instead of the more usual form of representation.

The methods illustrated in most of the diagrams are based upon the construction of recent buildings which have been designed by many leading architects. Therefore I do not claim them as my ideas or the result of my imagination. They are examples of modern practice and represent the manner in which modern buildings are being constructed.

E. G. W.

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INSETS

THE
FABRIC OF MODERN BUILDINGS

CHAPTER I

FOUNDATIONS

The term *foundation* usually applies to that part of a structure which is below the base of walls, piers, or stanchions and includes the ground upon which the base of the structure stands. The latter will be referred to throughout this book as the *foundation bed*, and the former as the *concrete foundations*.

Loads upon Foundations. If the loads of a structure exceed the bearing capacity of the material upon which the structure rests, the walls of the building will fail. Very little damage to the structure, however, will result from the settlement unless the building settles unevenly. Then stresses will occur in various parts of the structure and cause the piers or walls to fail. Therefore precautionary methods in construction must be adopted to secure uniformity of settlement.

If the loads of a structure are concentrated at various points, unequal settlement will naturally occur. Special precautions must be taken to ensure that the point loads are distributed over such an area of bearing surface as will be capable of carrying the loads so that the allowable unit pressure on the foundation bed is not exceeded.

A careful examination of the quality of the foundation bed should be made before the form of the concrete foundations is decided upon.

Subsoils. When rock forms the foundation bed, it is not necessary to spread the concrete foundations over a large area. It is usually sufficient to cut the rock to form a level bed, and to see that any natural fissures or pockets are filled in with good cement concrete.

When proceeding to erect buildings upon an ordinary earth and soft clay foundation bed, it is essential to spread the concrete foundations so as to distribute the weight over a large area.

Solid and ordinary clays make good foundation beds, but they must be kept fairly dry and protected from atmospheric influences. As such subsoils are affected by rain, heat, and frost, it is important that the concrete foundations shall be constructed at a depth below the surface of the ground which will ensure the insulation of the strata upon which the concrete foundations rest. It is essential also to distribute the weight over a large area by spreading the concrete foundations.

Sand will make a good foundation bed if it is confined and kept free from water scouring. To ensure against any lateral movement of the sand particles which may be caused by water scouring, it is advisable to protect the site by surrounding it with a system of sheet piling.

Gravel forms a good foundation bed because it has a high compressive resisting quality. Under ordinary circumstances it is almost incompressible and it is easily levelled and not affected by atmospheric influences.

When a structure is to be built on very soft, marshy, or made-up ground, the walls of the structure and the piers which are intended to transmit heavy point loads should be built upon a concrete foundation.

In its construction should be incorporated a system of piling so as to ensure against any possibility of sinkage. This danger will be overcome if the piles are situated so that the concrete foundations will rest directly upon the piles. Or a reinforced concrete raft may be formed over the whole site and supported upon the piles, which should be driven through the marshy soil and placed at intervals over the whole area.

Depth for Concrete Foundations. Where special circumstances or requirements do not exist, the following rough guide may be followed as to suitable depths for concrete foundations—

In gravel: 2 ft.

In ordinary soils: 3 ft.

In clay: 4 ft.

Site Tests. Before any particular form of concrete foundation is decided upon, tests should be made to ascertain the actual condition of the material upon which it is proposed to place it.

There are several methods of testing the condition and quality of the strata underlying the soil, but they are chiefly—

(1) Tests by digging pits in numerous positions over the site;

(2) Tests by a system of boring.

Quality of Foundation Bed. A good firm bed should possess the following qualities. It should be—

(1) Hard and solid;

(2) Equally compressible or incompressible throughout;

(3) Such that the stratification is horizontal.

London Building Act, 1930. Third Schedule; Section 23. Under this Act the pressure on foundations on natural ground shall not exceed the following—

(1) Natural bed of soft clay or wet or loose sand; 1 ton per ft.^{2}

(2) Natural bed of ordinary clay or confined sand: 2 tons per ft.^{2}

(3) Natural bed of compact gravel, London blue clay or chalk: 4 tons per ft.^{2}

With these figures it is necessary only to find the total weight of the structure to be carried; then ascertain according to the soil the superficial area required for the concrete foundations.

Code of Practice for the Use of Structural Steel and other Materials in Buildings. February, 1932.

Under the above code, Clause 47, the following are given as permissible loads upon various subsoils in tons per ft.^{2}—

Alluvial soil, made ground, very wet sand	Up to ½ ton
Soft clay, wet or loose sand	Up to 1 ton
Ordinary fairly dry clay, fairly dry fine sand, sandy clay	Up to 2 tons
Firm dry clay	Up to 3 tons
Compact sand or gravel, London blue, or similar hard compact clay	Up to 4 tons
Hard solid chalk	Up to 6 tons

"Intermediate values and values for other materials shall be agreed in consultation with the district surveyor. The above pressures may be exceeded by an amount equal to the weight of the material in which a foundation is bedded

and which is displaced by the foundation itself, measured downward from the final finished lowest adjoining floor or ground level."

Piling. Where it is intended to erect walls or piers to carry heavy loads on soft, marshy, or built-up ground, special treatment by piling is often necessary. There are various forms of piles such as timber, mild steel, concrete, or reinforced concrete.

Timber Piles. These are sometimes used, but they are giving place to some form of concrete or steel pile.

Mild Steel Piles. Although not in general use, mild steel piles have distinctive qualities which in certain circumstances demonstrate their utility.

They are really screw piles comprising a solid steel shaft fitted at the lower end with a steel helix, the pitch of which varies according to the nature of the ground into which the pile is to penetrate.

Sometimes hollow steel piles are used in preference to solid ones, in which case the internal core is removed and the cavity is filled with concrete if desired.

Precast Concrete Piles. Precast concrete piles are either cast in the manufacturer's yard or on the site. They are cast in the same fashion as long reinforced concrete beams, and are specially reinforced at the butt and point. A sketch showing the reinforcement for a reinforced concrete pile is given in Fig. 1.

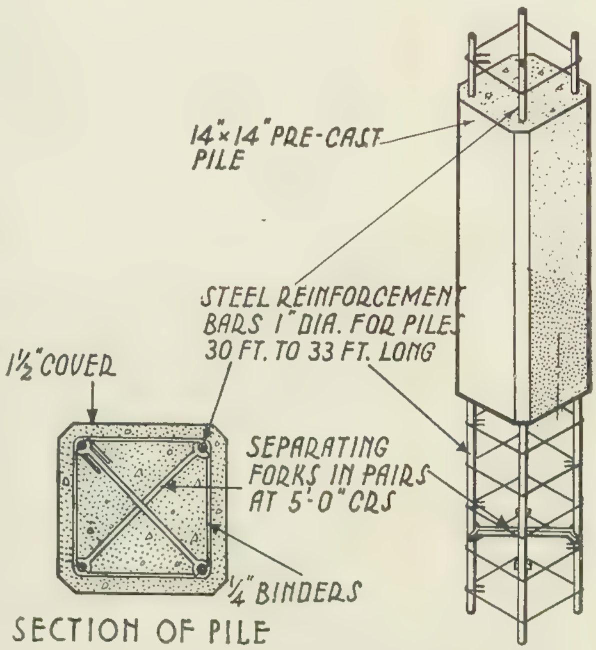

Fig. 1. Reinforcement for Concrete Piles

The sizes and lengths of precast piles are determined solely by the ease with which they may be handled and transported. The top portions of the vertical reinforcements are usually linked with those of the concrete foundations, as shown in Fig. 2. This sketch also shows the construction of a concrete raft supported upon a group of piles; and the base of a steel stanchion, surmounted upon a steel grillage, is shown in position relative to the group of piles.

Reinforced Concrete Piles cast *in situ*. Reinforced concrete piles cast *in situ* comprise a steel tube which is furnished with a tight fitting collapsible steel core. The pile penetrates into the ground to the required depth and the steel core is removed. The steel tube which remains is then filled with concrete after a system of reinforcing rods have been placed in position.

Pressure Piles. The piles are sunk by means of compressed air. The procedure is to bore with an auger and sink a lining similarly to the method adopted in artesian well boring. When the required depth is reached the bore hole is pumped dry and the reinforcement fully assembled. This is placed inside the pile lining and concrete inserted in about 6 ft. lengths. The pile cap is then made air-tight and compressed air is applied through it to the inside of the lining. As soon as the compressed air has made an air-tight chamber of the steel lining, the

pressure exerted acts on the cap of the steel lining and gradually lifts it away from the concrete. As the lining is lifted, the voids or irregularities are filled with the concrete which remains under pressure.

CAISSON PILES. These consist of short steel cylinders set one upon the other and bolted to each other, whilst the bottom of the lowest cylinder is provided

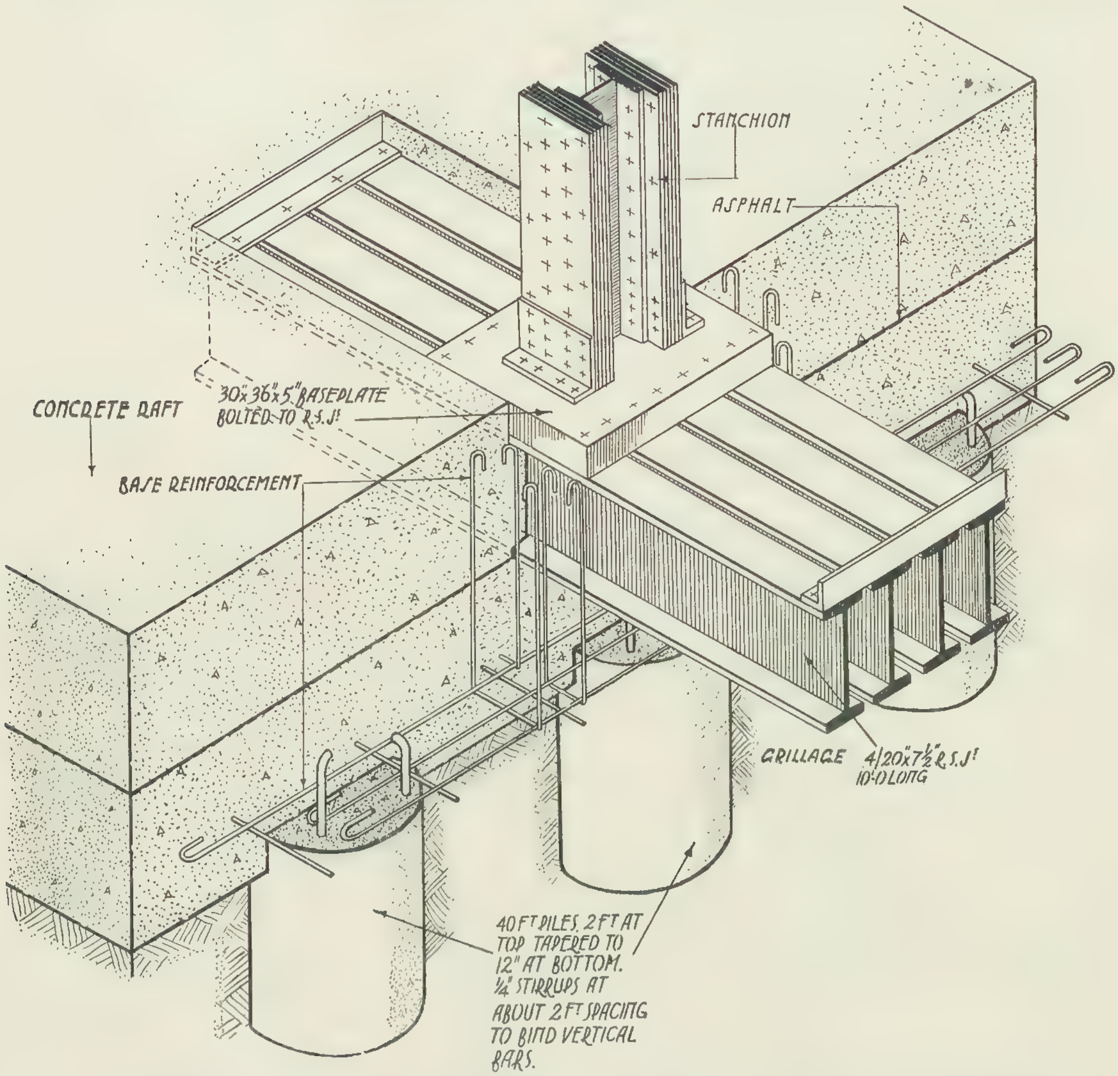

FIG. 2. REINFORCED CONCRETE RAFT RESTING UPON A GROUP OF REINFORCED CONCRETE PILES

with a cutting edge. Caisson piles are not driven, but are allowed to sink, either by their own weight, or by superimposing loads. The caisson must be of sufficient sectional area to permit a man to work inside to remove the earth. Thus the cylinders can sink as the earth is excavated from the vicinity of the cutting edge. When the desired depth has been reached, the cylinders are lifted as the concrete is placed in position. When it is desired to penetrate soils containing an excessive amount of water, caissons are fitted with air locks.

SHEET PILES. These are of timber or steel and are usually proprietary articles, being made to special sections adopted by the manufacturers. Their chief function is to prevent the displacement or lateral movement of the soil, or to keep water from deep excavation work.

Spacing for Piles. When arranging for the spacing of piles, care should be exercised to see that they are not driven too closely together. In the case of beam foundations, a single row of piles under the concrete beam foundation is often sufficient, as shown in Fig. 3.

In other circumstances groups of piles are necessary. The piles are then

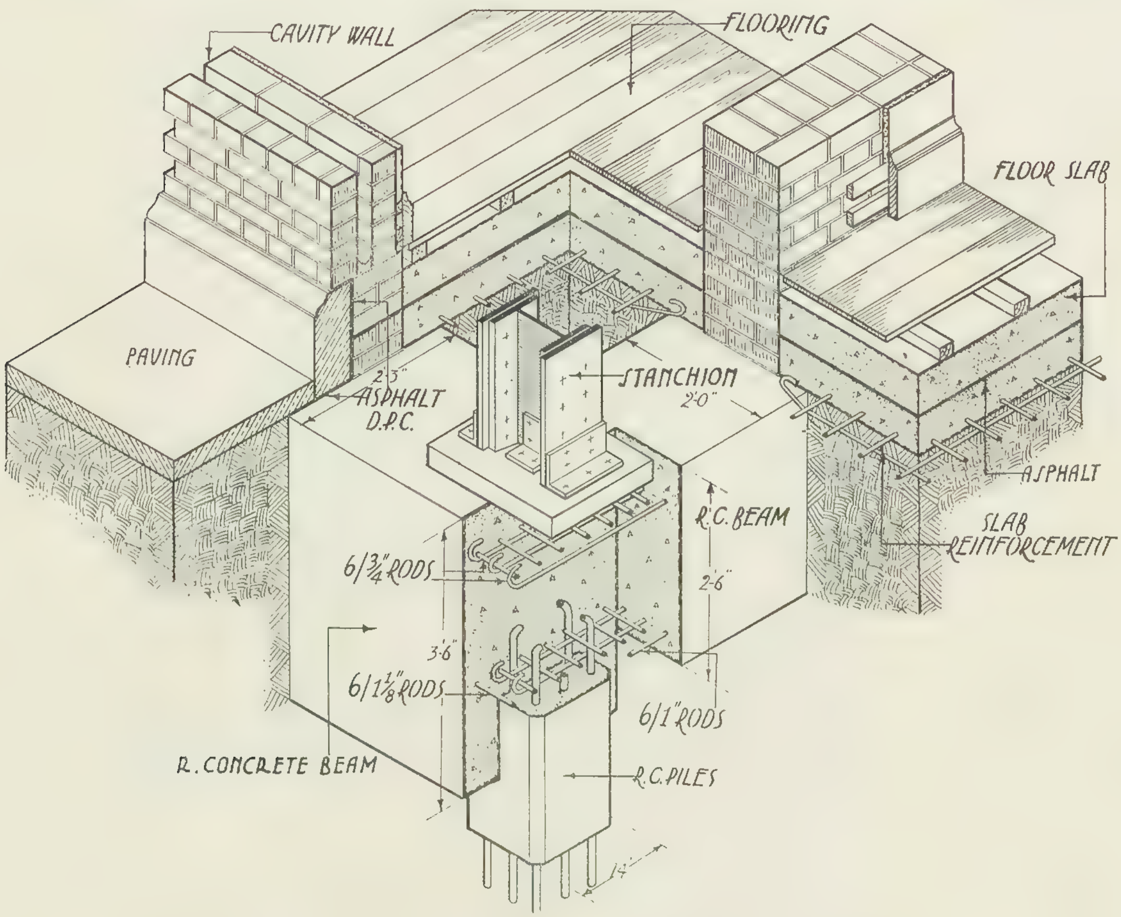

Fig. 3. Reinforced Concrete Pile and Beam Foundations

placed in rows or else staggered. In any case the centre of gravity of the cluster should coincide with the centre of gravity of the load, as in Fig. 4.

Concrete Foundations

Concrete Foundations to Walls, Piers, etc. Unless the foundation bed is composed of rock it is necessary to place a bed of concrete immediately beneath the bases of walls, piers, and stanchions. The width or superficial area of the concrete foundations should be such that the loads will be equally distributed over an area of ground which will safely support them; and the concrete foundations should be of such a thickness that there will be no likelihood of fractures occurring in them.

Concrete, whether plain or reinforced, is the best and most economical material for such purposes; because it becomes monolithic in structure, and therefore most suitable for transmitting the loads over large areas of ground.

The most common type of concrete foundation is that required for a brick

wall (Fig. 5). It is usual to make the concrete foundations for such walls to conform to local by-laws without resorting to calculations.

L.C.C. By-laws Regarding Foundations. The L.C.C. By-laws state—

"The foundations of walls of every house, or building, shall be formed of a bed of good concrete not less than 9 in. thick and projecting at least 4 in. on either side of the lowest course of the footings of such walls."

For buildings of more than two stories in height, the area and thickness of the concrete bases should be calculated and the concrete foundations designed so that an allowable stress unit of 500 lb. per in.^{2} is not exceeded.

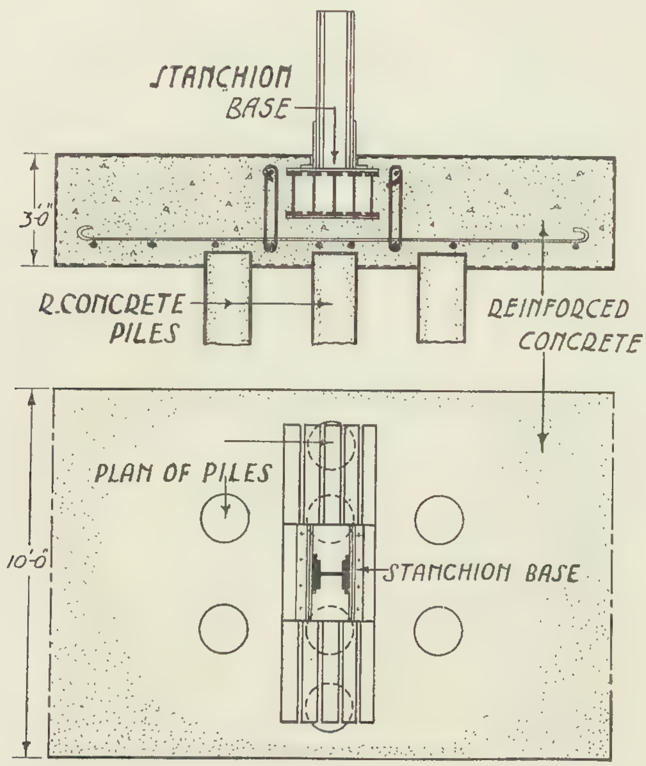

Fig. 4. Grouping for Piles

The width of concrete foundations for walls may be found by calculation if desired by dividing the total load per linear foot of wall by the safe permissible load on the soil.

Thickness of Concrete Foundations. The thickness of concrete foundations may be ascertained in the following way—

The concrete under the footings is considered as being subjected to compression stresses only, whilst the concrete extending on either side of the footings must be considered as cantilevers with distributed loads equal to the pressure exerted by them on the earth. For the purpose of calculation the concrete should be considered to have a tensile value of 50 lb. per in.^{2} (assuming a 6 to 1 Portland cement concrete). The thickness may be calculated from the following formula—

B.M. $=$ M.R. (bending moment $=$ moment of resistance).

$$Wl^2/2 = fbd^2/6. \quad \therefore d^2 = 6Wl^2/2fb.$$

and depth $d = \sqrt{(6Wl^2/2fb)}$,

where W = load in lb. per in. length of span;
l = length in in.;
f = safe tensile strength of concrete in lb. per in.^{2};
b = breadth in in.;
d = thickness in in.

Concrete Slab Foundations. An illustration of this type of concrete foundation is given in Fig. 5.

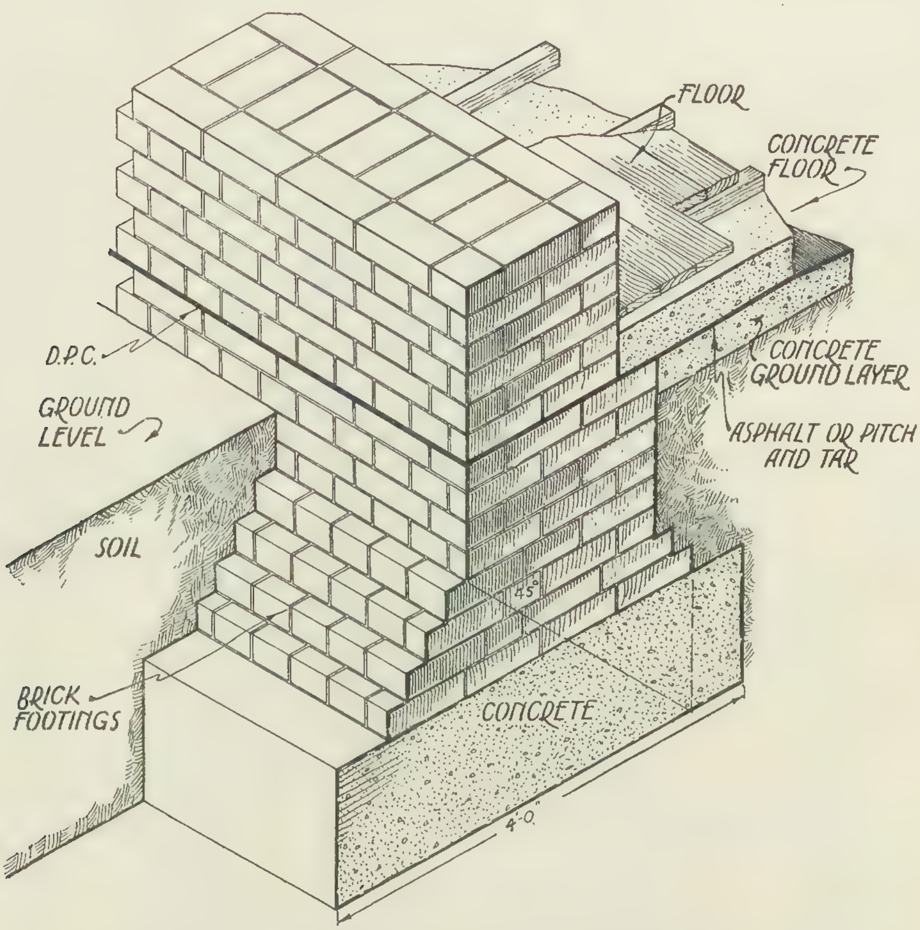

Fig. 5. Typical Concrete Foundations for a Brick Wall

As already described, the depth of the concrete must be such that it will not fail, or fracture, when the load is applied.

In practice various methods are used for determining the correct depth of the concrete. For ordinary purposes it has been ascertained that such fractures usually occur in a direction corresponding to an angle of 45° from the face of the wall, as shown in the sketch.

Reinforced Concrete Slab Foundations. If the soil is such that a greater superficial area is required, and the concrete foundation has to be further extended on either side of the wall, it is usual to insert steel reinforcement bars in the concrete to counteract the tension in bending, which will be at its maximum at the bottom of the slab. The inclusion of the steel reinforcement will permit the use of a thinner concrete slab than would be otherwise required. This should consist of hooked steel rods, placed so that they resist the tendency to failure

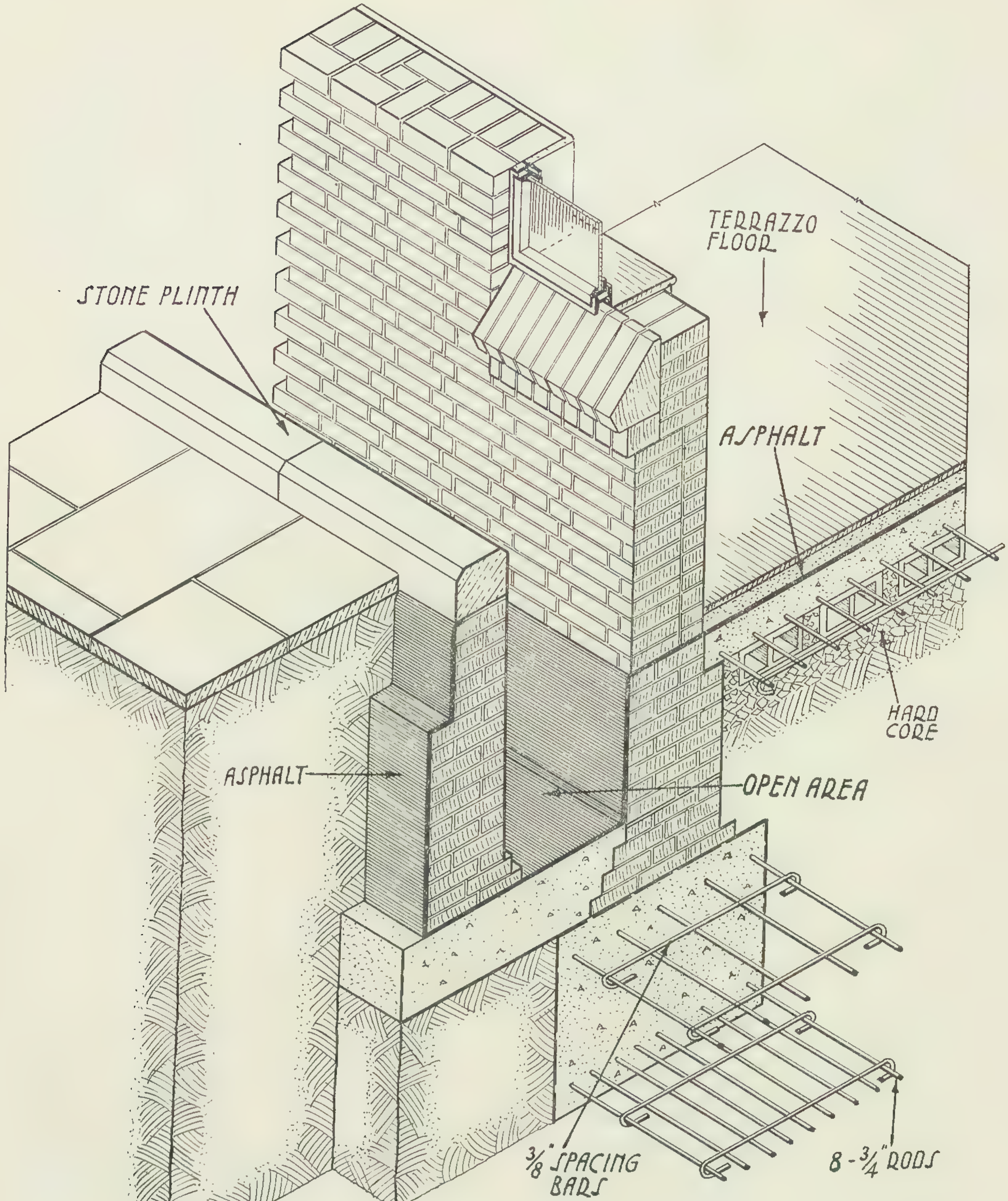

FIG. 6. REINFORCED CONCRETE BEAM FOUNDATIONS FOR A BRICK WALL

through bending, or shearing. Therefore such reinforcement should be placed as near as possible to the bottom of the slab. It will be noticed that the formula given for determining the thickness of the concrete foundations depends for its result upon the length of the projection of the concrete on either side of the base of the wall; therefore, by inserting steel reinforcement bars in the concrete, economies may be effected over the use of plain concrete.

The thickness of the slab will largely depend upon the amount and arrangement of the reinforcement.

Reinforced Concrete Beam Foundations. Steel and reinforced concrete framed structures are generally formed in such a way that they will transmit their loads to the foundations through piers and columns or stanchions. If the

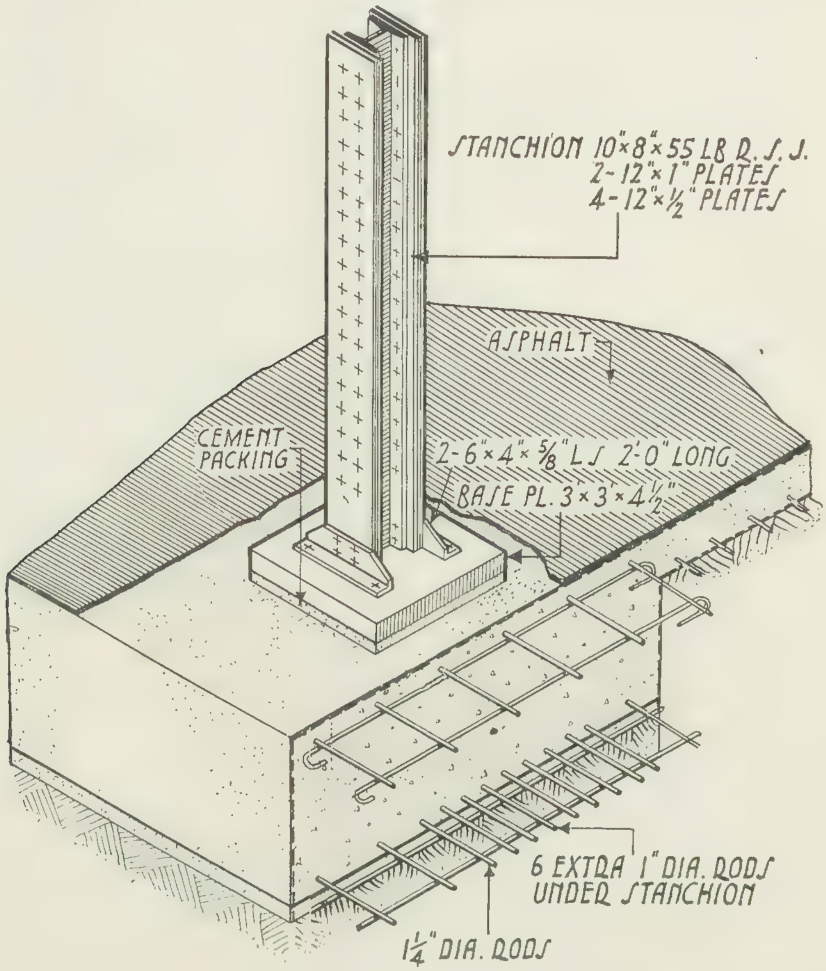

Fig. 7. Reinforced Concrete Beam Foundations for Steel Stanchions

foundation bed is good, the concrete foundations may be made by forming a reinforced concrete beam. The beam should be continuous throughout the length of the walls, and the reinforcing rods should be placed so that the beam will be capable of resisting the maximum point loads which are transmitted through the columns or stanchions.

Fig. 6 shows a reinforced concrete beam foundation for a brick wall: it also shows the construction of an open area and dwarf wall, together with a suitable arrangement for preventing dampness penetrating the walls of the structure.

Fig. 7 is a sketch detail through a reinforced concrete beam foundation suitable for the transmission of loads from piers and stanchions.

Reinforced Concrete Foundations to Piers and Stanchions. Such a foundation may be considered as an inverted cantilever beam on each side of the pier and uniformly loaded by the upward reaction of the ground. The area

and depth of concrete foundations under piers and stanchions may be calculated in a manner similar to that already described.

The projection of the concrete foundations on either side of the face of a pier or stanchion base may be considered as an inverted cantilever beam uniformly loaded, and such foundations must be of sufficient depth to resist shear. As the

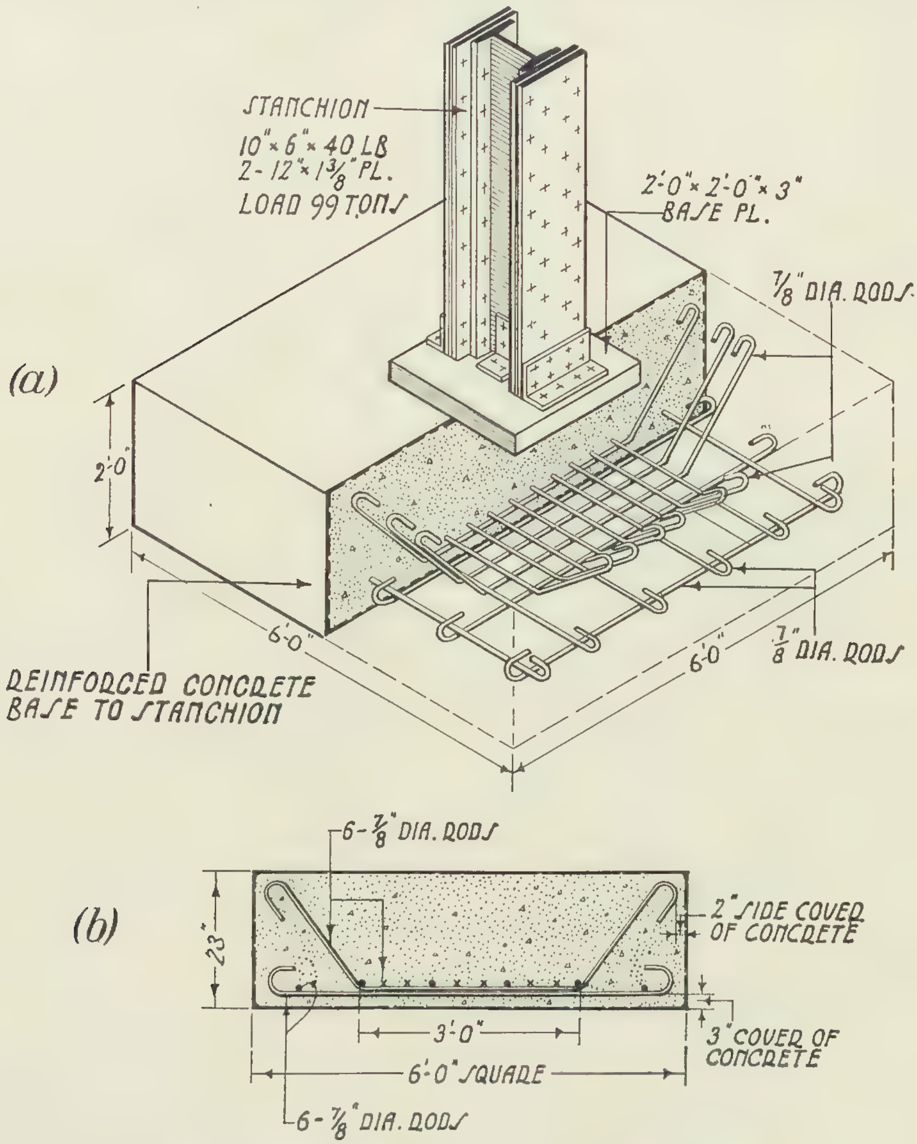

FIG. 8. REINFORCED CONCRETE PIER FOUNDATIONS

(*a*) Reinforced concrete foundations for steel stanchions.
(*b*) Section through a reinforced concrete foundation.

maximum bending moment is at the face of the base of the pier or stanchion, hooked reinforcing rods should be placed in the concrete in both directions and at right angles to the faces of the pier or stanchion, also as near to the bottom of the slab as possible, as in Figs. 8 (*a*) and 8 (*b*). Sufficient concrete covering should be allowed so as to exclude dampness from the reinforcement.

Reinforced Concrete Beam or Continuous Spread Foundations. For stanchions carrying external walls, it is often impossible to spread the concrete foundations owing to the close proximity of the boundary line to the building line.

In such cases, reinforced concrete beams or continuous concrete foundations may be utilized as shown in Fig. 9. This also shows how such foundations may be insulated from dampness.

The superficial area required for concrete foundations to support the concentrated loads transmitted from the stanchion is calculated in the same manner

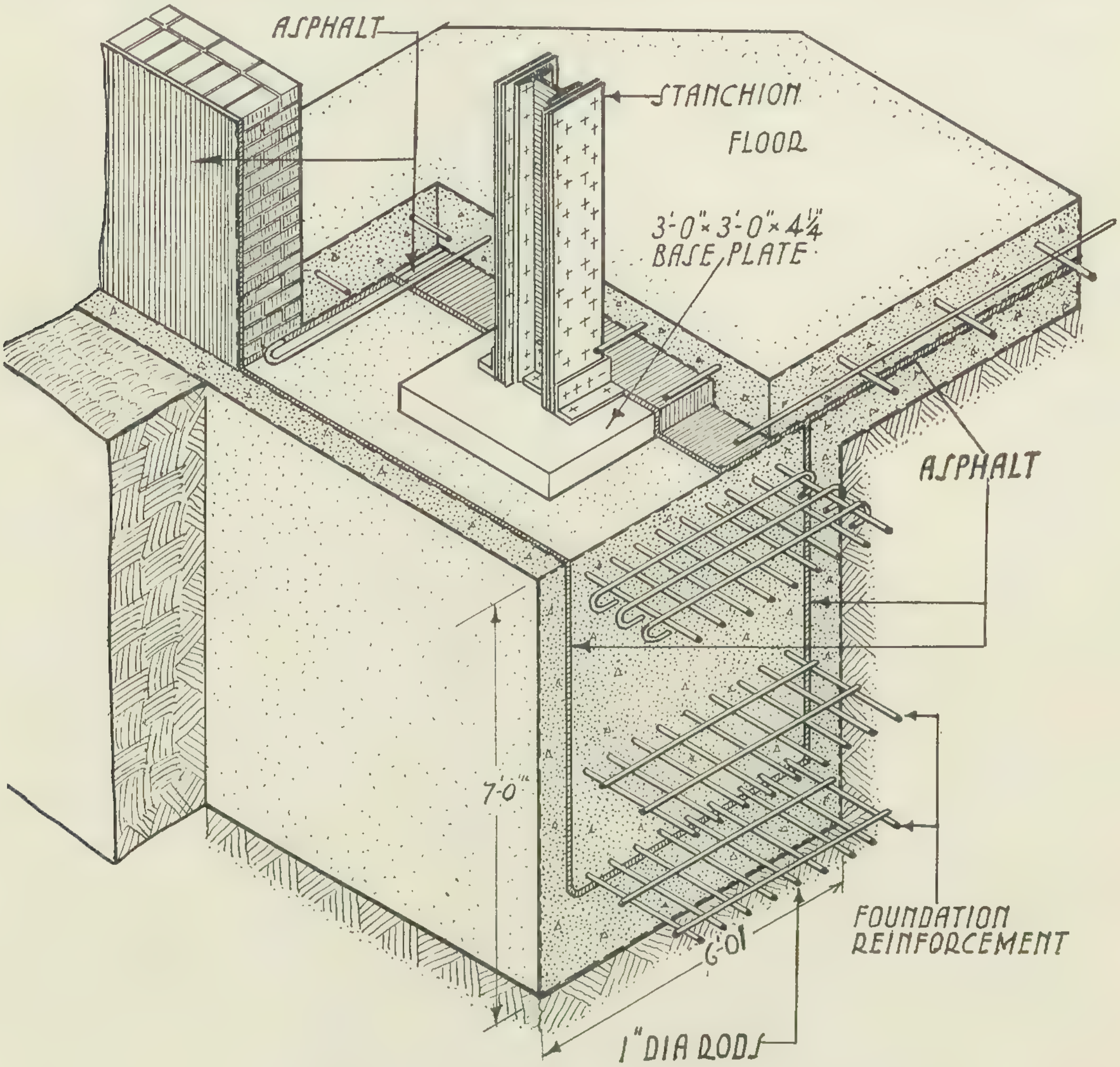

Fig. 9. Continuous Spread Foundations in Reinforced Concrete

as for rectangular concrete foundations suitable for an independent column or stanchion.

If the concrete foundations are extended parallel to the building line, so that they connect up with the concrete foundations of the adjacent stanchion, they will form an inverted continuous beam uniformly loaded and supported by a series of columns.

The required length for the concrete foundations may be ascertained by dividing the total load on the stanchions by the safe permissible load on the soil, and then dividing the resultant by the maximum allowable width of the concrete foundations. If this length is found to be insufficient to connect up with the concrete foundations of the adjacent stanchion, then an extra length of concrete

must be added. This will form a continuous inverted beam supported by the stanchions and uniformly loaded by the upward pressure of the soil.

In making these calculations allowance must be made in the total loads for the weight of the concrete foundations. If, however, the distance from centre to centre of the stanchions is insufficient for the required superficial area, then the width of the concrete foundations must be increased, or a concrete foundation formed which will combine with one of the interior stanchions.

When the distance from centre to centre of the stanchions is known, and the distance from the boundary line to the centre of the external stanchions will permit, the width of the concrete foundations may be determined by dividing the superficial area required by the length, which itself is determined by the distance from centre to centre of the stanchions.

Longitudinal and transverse steel reinforcement bars may be inserted in the concrete foundations, their arrangement and quantity being determined by calculations as for a reinforced concrete continuous beam.

Other Forms of Foundation

Pile and Reinforced Concrete Beam Foundations. The construction of suitable concrete foundations in marshy soils is a very difficult problem. It often necessitates the inclusion of a system of piling over the whole of the site, or piles may have to be placed so that they support the external and internal walls of the structure. In the latter case the walls may be built upon reinforced concrete beams which are connected to, and supported upon, reinforced concrete piles. This construction will dispense with the concrete spread foundations and footings. Fig. 3 shows an external wall built upon a pile and beam foundation.

Pier and Reinforced Concrete Beam Foundations. When a thin stratum of soft soil overlays rock or a hard solid stratum, a system of piers constructed of concrete or brick may be used in preference to a system of piling.

Excavations or pits are dug through the soft soil to the rock or solid stratum. Then the piers are built up from a concrete base so as to support the walls of the superstructure.

When this method of foundation is adopted the walls of the superstructure may be carried upon the reinforced concrete beams which are formed to span from pier to pier as shown in Fig. 10. In this example blue brick piers are shown supporting reinforced concrete beams which form the base of the external and cross walls. The chimney breast shown in the illustration is carried up direct from one of the piers, whilst the construction of the hearth, fireplace opening, and the gathering over of the flues may be seen. This type of foundation is suitable for large domestic dwellings, residential flats, etc.

The illustration also includes the construction of a concrete ground floor and shows the arrangement and position of the damp-proof courses.

Raft Foundations. Raft foundations may be constructed in plain or reinforced concrete.

The choice will depend very largely upon the particular conditions of each case and also upon the nature of the soil over which the raft is to be formed. Raft foundations are particularly suitable for construction over sites where the bearing power of the soil is insufficient for the adoption of independent concrete foundations, or concrete foundations which are intended to take the point loads transmitted from piers, stanchions, etc.

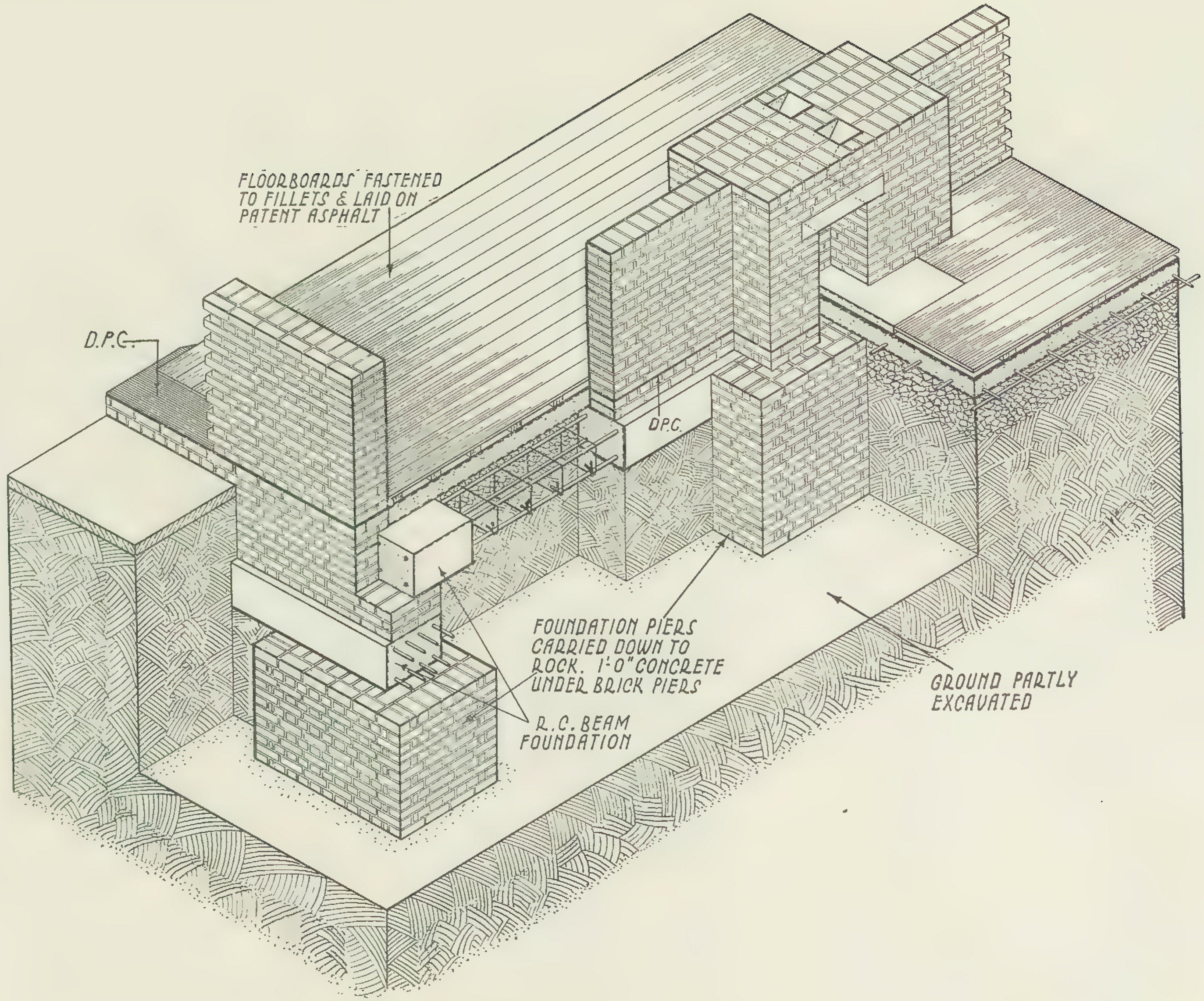

Fig. 10. Reinforced Concrete Beam Foundations Resting on Brick Piers

A system of piling may not meet the requirements of all conditions, but a piling system may be combined with a raft foundation.

For covering the sites where the bearing power of the soil is very uneven, the construction of a reinforced concrete raft foundation is more economical than a raft constructed of mass or plain concrete. There is also less likelihood of injury to the fabric of the building should a settlement occur, because it is monolithic and will permit such settlement as a complete unit.

Reinforced concrete rafts may be formed in similar fashion to beam and slab floor construction, but reversed; which means that the forces will be assumed

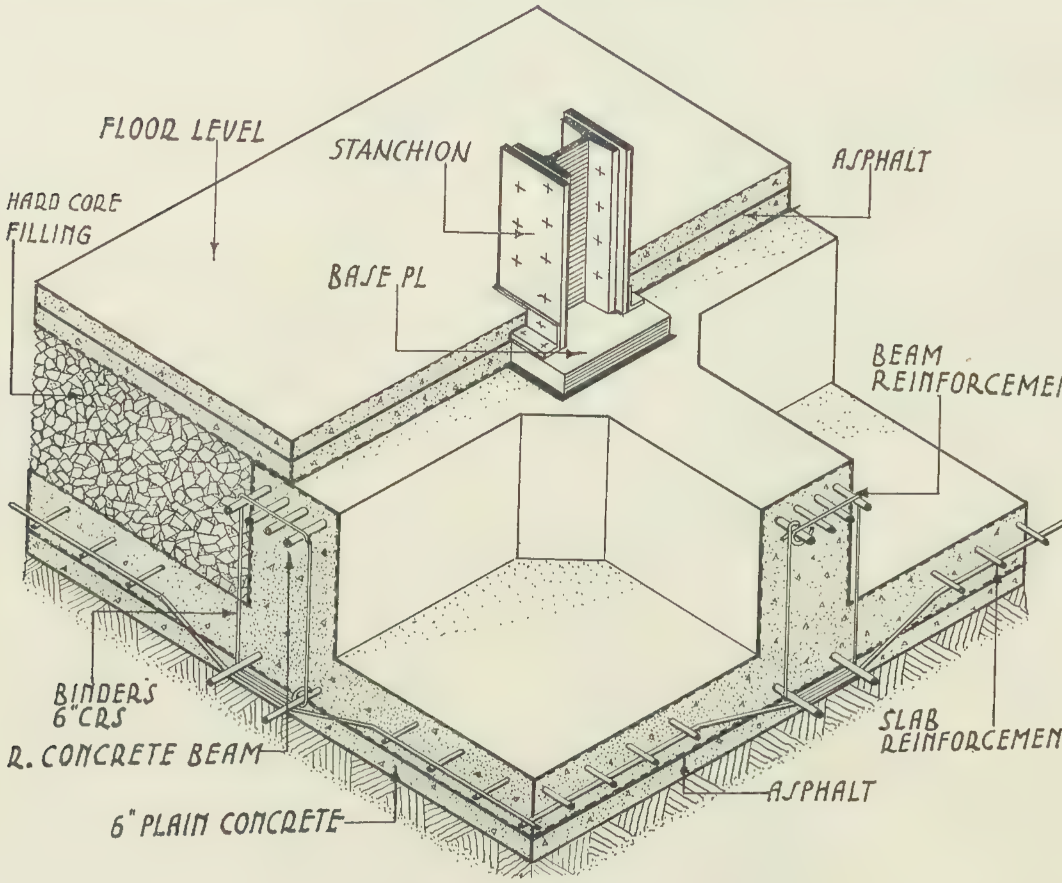

Fig. 11. Reinforced Concrete Raft Foundations

to act in an upward direction or invertly. In this method of construction, the beams are formed so as to span the distance between the point loads; whilst the areas between the beams are covered with panels, or slabs of concrete, reinforced with a system of steel rods, similar to slab and beam construction in floors. The reinforcement bars should be placed in the upper portion of the slabs where they will counteract the tension in bending.

A floor surface may be formed on top of the beams as shown in Fig. 11. Then the spaces between the beams should be filled with hard-core to form a seating for casting the floor slab.

If however the soil over a site is very compressible and likely to flow, owing to the squeezing out of the soil, or when the compressible overlying soil continues for some depth below the ground level, a system of piling may be combined with the raft construction. If the foundation bed is of wet sand, a system of sheet

piling should be incorporated with the raft foundation. These piles should surround the site and be driven down to a depth below which any subsequent excavations are likely to be made. The sheet piling will prevent the disturbance of the foundation bed, should the water under the foundations be removed by any agency.

In some instances caissons are sunk through an overlying soft marshy soil until a hard and solid foundation bed is reached, and a reinforced concrete raft is then constructed so as to rest upon the piers formed in the caissons.

CHAPTER II

WALLS

Brick Footings

Footings for Walls. To conform with the requirements of the L.C.C. by-laws it is necessary to construct footings at the bases of walls. These footings should be formed by increasing the width of a wall at its base by regular offsets or projections on both sides, so as to spread the weight of the wall over a larger area of soil (see Figs. 5–12). Each course of bricks should project $2\frac{1}{4}$ in. on each side of the wall, until a total width equal to twice the width of the wall is

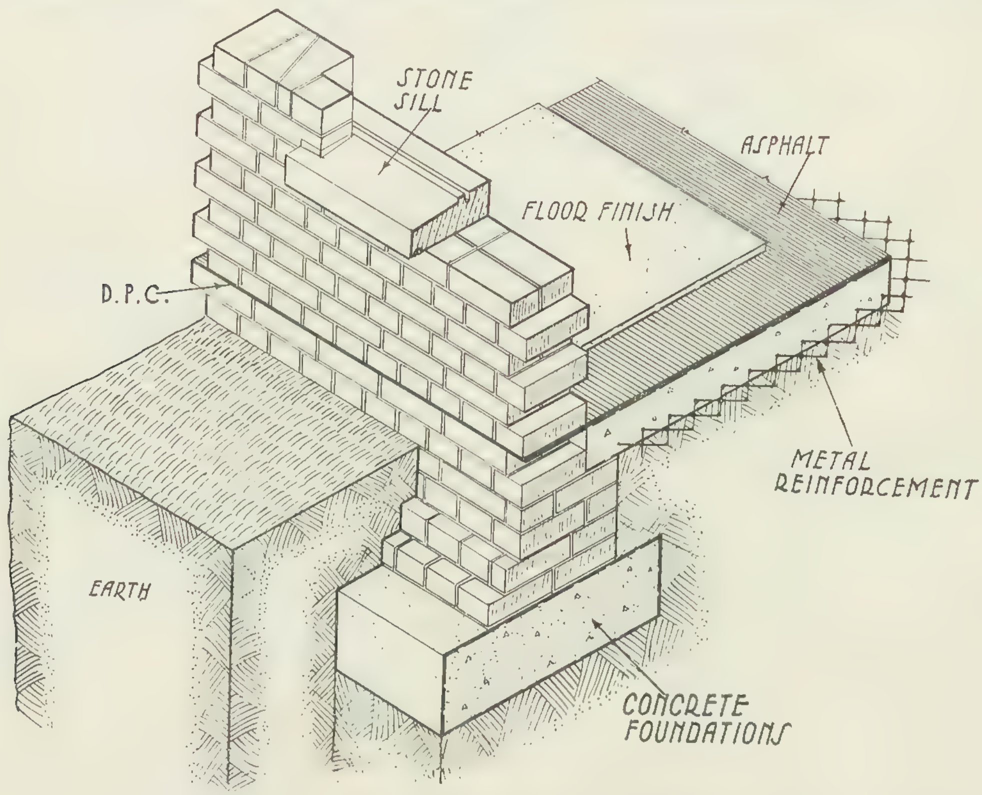

Fig. 12. Base of Brick Wall and Reinforced Concrete Ground Floor

obtained, and there should be one course of footings for every half-brick thickness of the wall.

The construction of brick footings is obviously wasteful and extravagant in material and labour. It is also out of date; for with the use of good Portland cement concrete brick projections are no longer required, since the concrete can be benched up so as to function in a manner similar to brick footings.

The omission of brick footings may mean an increased thickness for the concrete foundations, but this increase would be justified by the amount of material and labour saved.

Some by-laws will permit walls to be constructed without footings as in Fig. 13. This shows a section through the base of a wall without footings. The concrete may be benched, thereby preventing waste of material.

The brickwork for footings should be built in header bond; and where stretchers are necessary to make up the width of the course, they should be placed as near as possible to the centre of the wall.

Footings for Piers. These should be constructed in the same way as wall footings, and the footings should extend equally on all sides of the pier. Footings for attached piers should be similarly made. Fireplace openings, which are formed by building attached piers on each side of the opening should, according

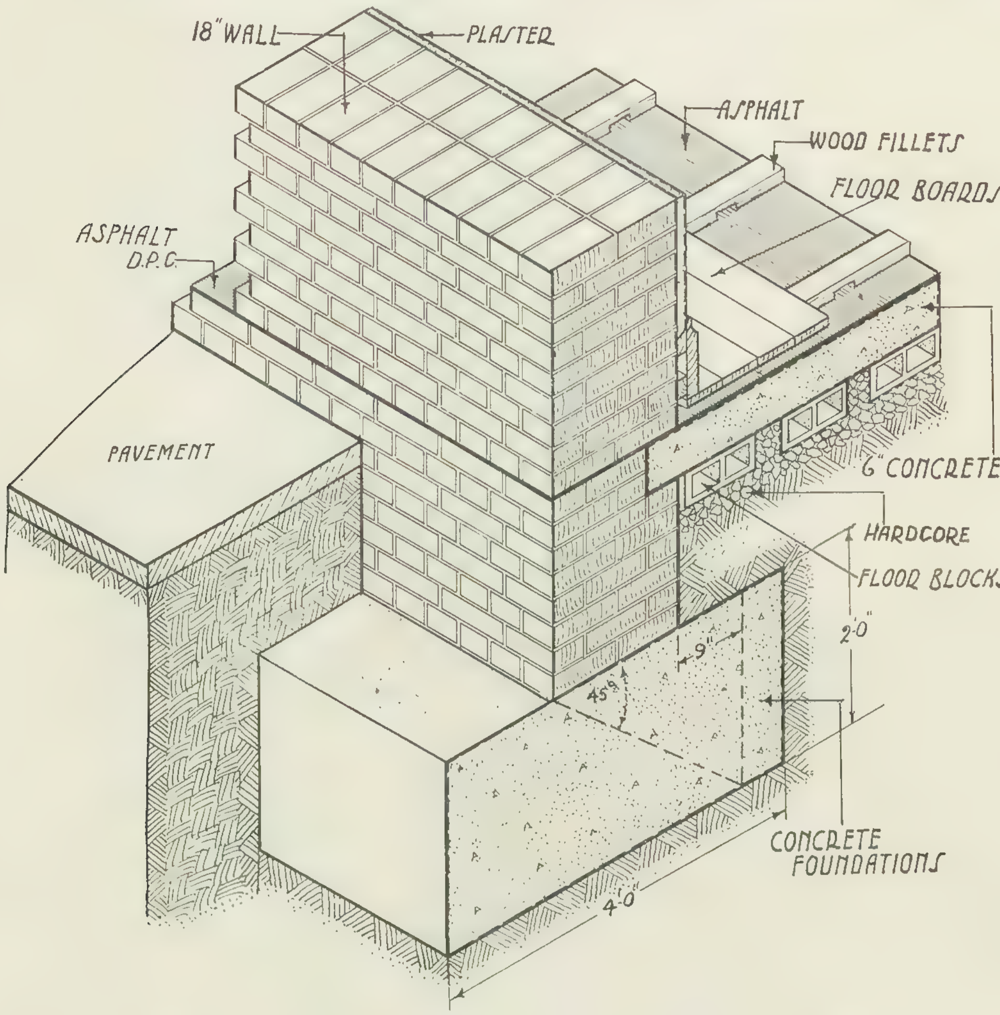

Fig. 13. Section Through Base of Wall Without Footings

to some by-laws, have footings projecting on each side of the piers. This procedure is obviously unnecessary as concrete could serve the same purpose.

The introduction of modern materials into building construction has caused changes to take place in the method of constructing bases to walls. The use of steelwork and reinforced concrete has caused the loads of a structure to be concentrated at various points throughout the site, instead of being evenly distributed along the entire length of the walls.

The loads of framed structures should be transmitted to, and carried by, the framework, and not independent of the framework. It has taken many years to appreciate this important fact, hence we see the external walls of many buildings being constructed as if there were no structural framework.

Bases to Reinforced Concrete-framed Structures. Fig. 14 shows the base of a reinforced concrete-framed structure. It will be seen that the external wall is carried on a reinforced concrete beam which is connected to the reinforced concrete column or stanchion and situated just below ground level. The columns

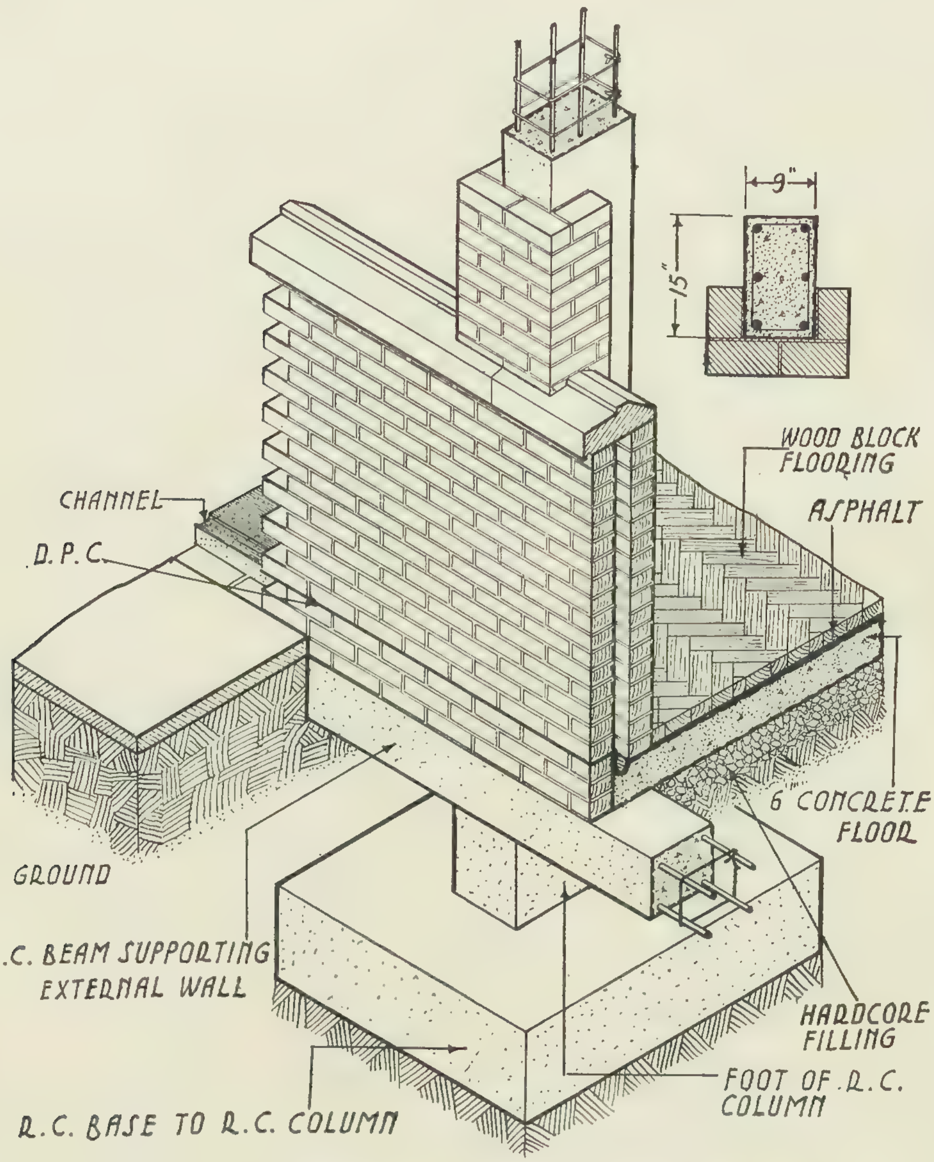

Fig. 14. Base of Reinforced Concrete Framed Structure

transmit the weight of the wall to the concrete foundations or the bases of the columns.

This type of construction has many advantages over those previously illustrated. It will be noticed that not only are the footings dispensed with, but the enclosing walls of each floor may be removed to accommodate future extensions without interfering with the structure or the enclosing walls above or below. Fig. 15 shows the arrangement of the reinforcement bars in the column and base shown in the previous diagram.

Steel Stanchion Bases. The function of a stanchion base is to receive the

load from the stanchion, and transfer it uniformly over its whole area to the concrete foundations without exceeding the allowable unit bearing stress in the concrete. If the end of the steel stanchion were to rest directly upon the concrete foundations, the latter would tend to crush, because the allowable unit com-

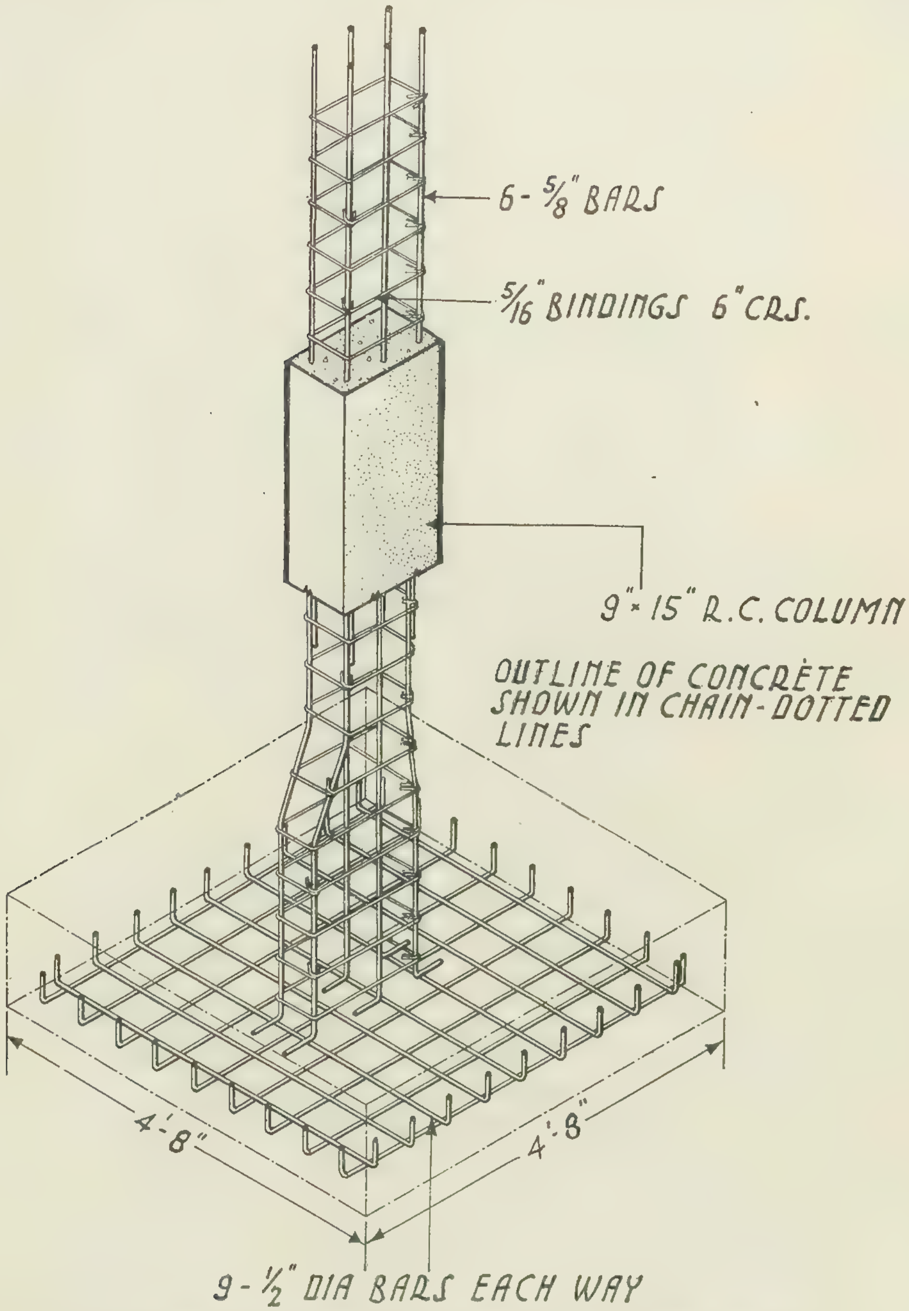

FIG. 15. ARRANGEMENT OF STEEL REINFORCEMENTS FOR COLUMN AND BASE

pressive stress in steel is much greater than the ultimate compressive stress in concrete. Therefore the load transferred from the stanchion to the base must be distributed over a large area of concrete so that the allowable stress is not exceeded.

Gusset Bases. Stanchion bases may be formed by connecting wide plates

called *gusset plates* and angle sections to the stanchions so as to extend the dimension of the stanchion section to the required superficial area. These angle sections are also riveted to a base plate which should be of sufficient superficial area and also to form a seating for the stanchion. Figs. 16 and 17 illustrate two types of gusset bases.

Cast Iron Bases. Fig. 18 shows a cast iron base resting upon a reinforced

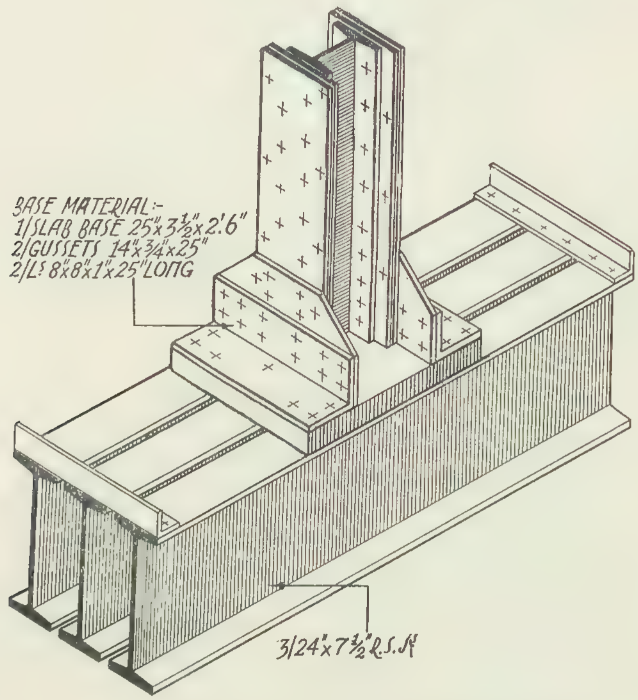

Fig. 16. Gusset Type of Stanchion Base

concrete sub-base. This sub-base is designed to take the place of a steel grillage, and the stanchion base is anchored to the concrete base by means of steel sections which are clipped over the base at each of the four corners.

Bloom Bases. This type of base consists of a rolled steel slab of a thickness which is calculated as sufficient to resist the bending moments; it is connected to the stanchion by means of angle sections only. Bloom bases are those most generally adopted, and they have displaced almost entirely the gusset type, or cast iron bases for stanchions which are subjected to heavy loading. Figs. 2, 7, 8 (*a*), 9, and 19 may be taken as typical examples of bloom bases.

Area of Bloom Base. When a bloom base rests directly upon the concrete foundations, the area of the base or bloom is determined by dividing the column load by the allowable stresses per square foot for concrete, which in clause 48 of the *Code of Practice for the Use of Structural Steel and Other Materials in Building* is given as 30 tons per ft.^{2}, this figure being for a 1, 2, 4 cement concrete mix. Figs. 8 (*a*) and 8 (*b*) illustrate a bloom base to a steel stanchion supported upon a reinforced concrete foundation. It will be noticed by reference to the sketch that the total load on the stanchion is given as 99 tons, and the area of the bloom base is 4 ft. super. A suitable arrangement of the reinforcing bars in the concrete foundation is clearly shown.

Steel Grillages. Very heavy concentrated loads on stanchions often necessitate the formation of multiple bases so as to spread the loads over a larger area

than can be accomplished with a single base. This entails the introduction of steel grillages, as may be seen in Fig. 16.

These grillages really take the place of footings and consist of one or more layers of rolled steel joists. The joists are placed side by side in one, two, or three tiers, and bolted together and attached to the stanchion base. The direction of the beams in each tier is at right angles to those in the tier adjacent,

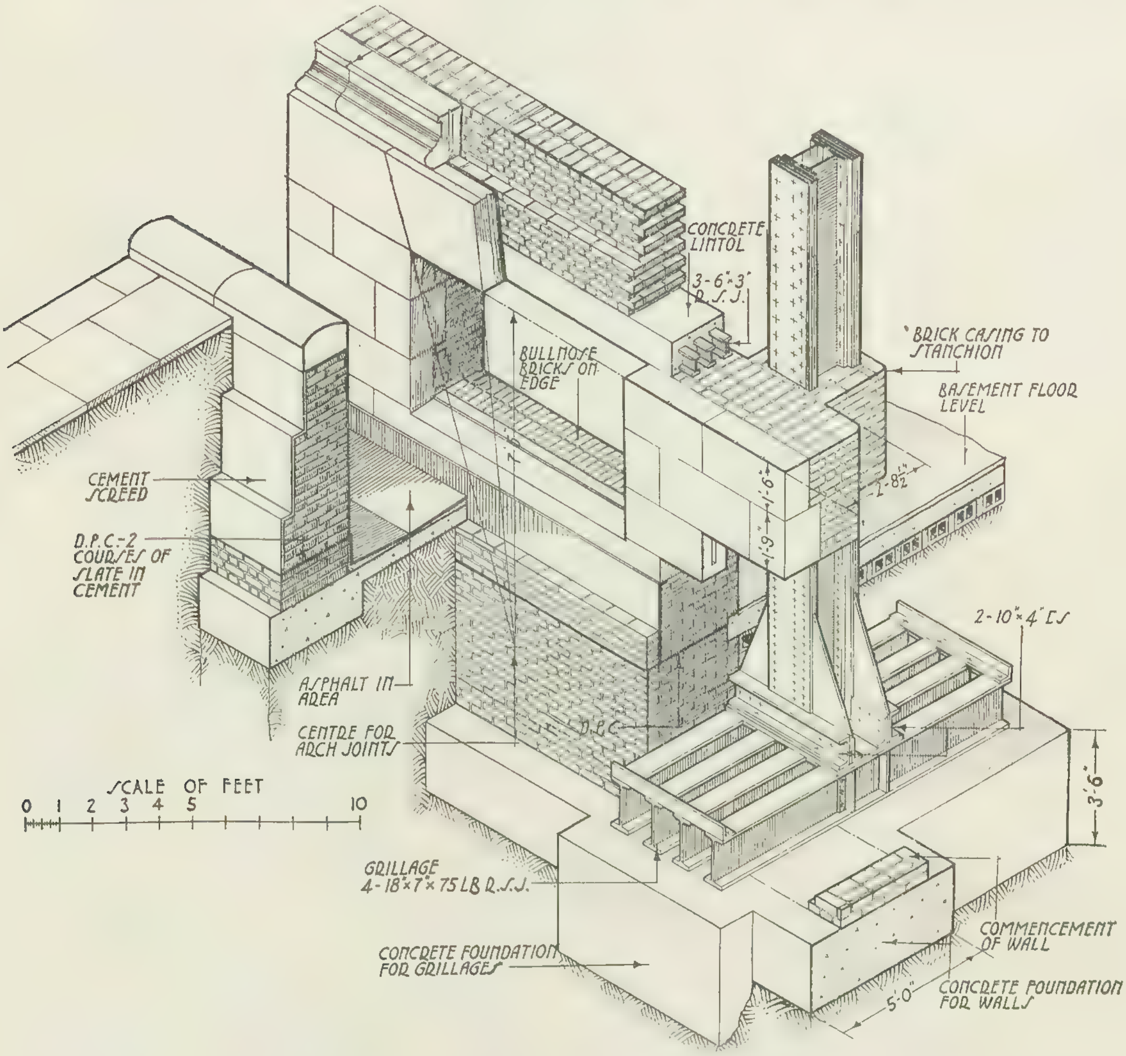

Fig. 17. Gusset Type of Stanchion Base and Steel Grillage Foundation

above or below. The upper tier receives the concentrated loads and distributes it to the lower tier, which in turn distributes it to the concrete foundations. The number of tiers depends upon the loads and the bearing capacity of the foundation bed. The spaces between the beams in each tier should be filled with concrete, thus making a solid concrete block.

Fig. 19 illustrates a two-tier steel grillage. A steel grillage as used in conjunction with the construction of an external wall may be seen in Fig. 17.

Retaining Walls

Retaining walls are designed to withstand the lateral pressure of the earth which is adjacent to the wall, and to prevent the earth from sliding when the

slope of the earth exceeds the slope of stability. Also they may be designed to act in a double capacity by forming the base of a superimposed structure as shown in Fig. 21.

Masonry and Concrete Retaining Walls. Retaining walls built of brick, stone, or plain concrete should be designed and proportioned so that the weight

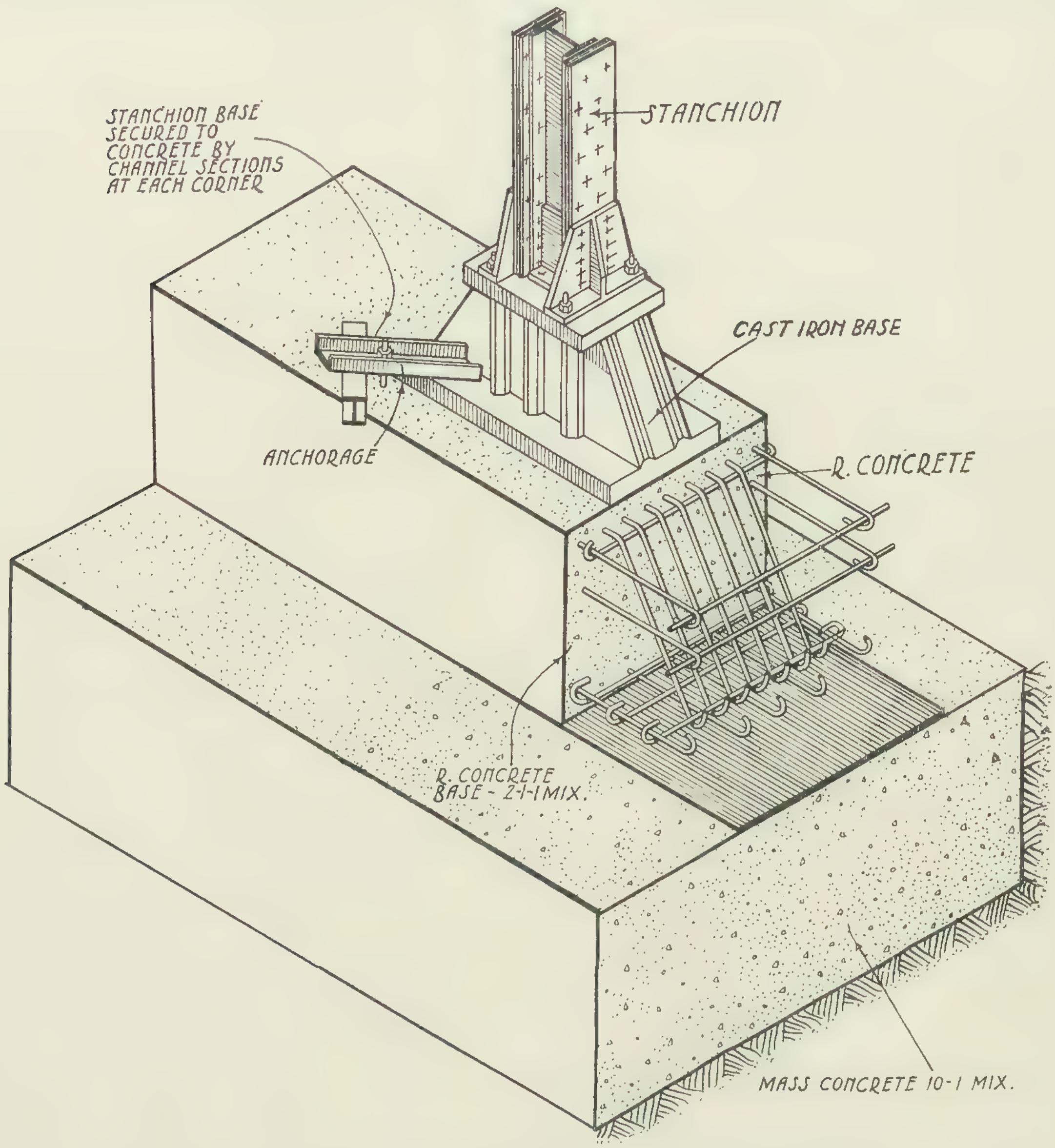

Fig. 18. Cast Iron and Reinforced Concrete Stanchion Bases

of the material composing the wall is sufficient to resist overturning or sliding. The proportions for such walls will depend upon the depth of the excavations and the character of the strata behind the walls or the materials which are to be retained in their correct position.

Retaining walls are often in danger of sliding under very heavy thrusts; therefore when the resistance depends entirely upon the weight of the wall, it is necessary that the wall shall be designed to resist this possibility.

The design of a retaining wall will be governed very largely by the conditions

peculiar to each erection. If the boundary limit is some distance in front of the building line and economy in space is not of paramount importance, and if, too, the depth of the excavation is only intended for a single basement floor, the retaining wall may be built in mass concrete as in Fig. 20, and an open area may be formed in the space between the face of the building and the retaining wall.

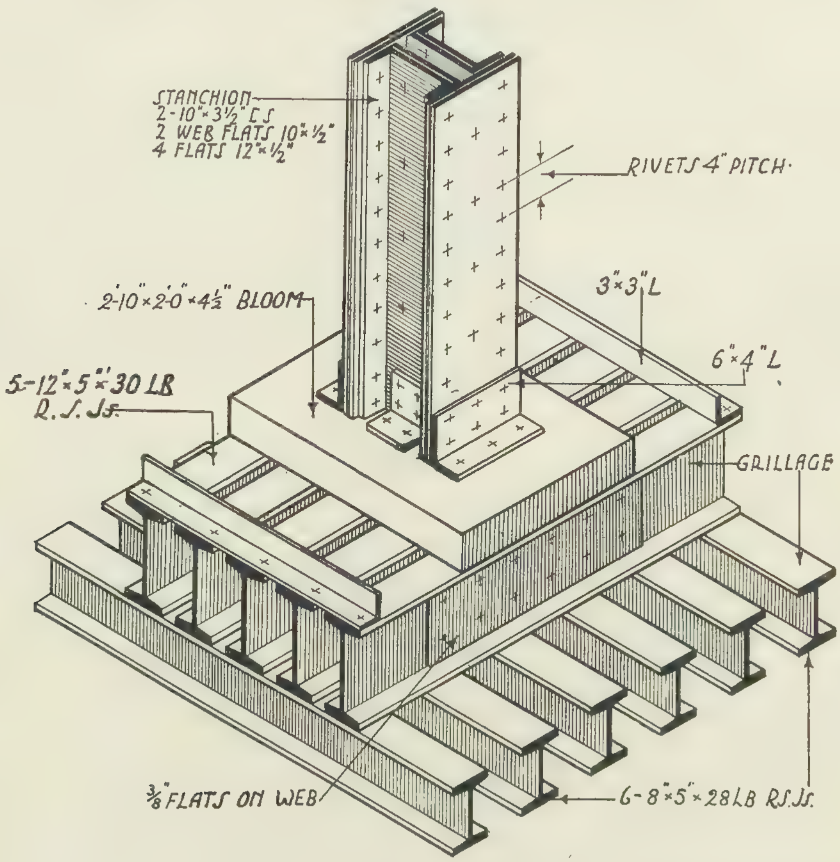

Fig. 19. Bloom Type of Stanchion Base and Steel Grillage Foundation

In this instance the weight of the material in the wall is sufficient to retain the earth; so that the wall does not have to depend upon or receive support from the weight of the superstructure of the building.

Reinforced Concrete Retaining Walls. Where deeper excavations and multiple basement floors are desired, it is more economical to design the retaining wall in reinforced concrete.

The principle upon which reinforced concrete retaining walls is constructed is to form a monolithic structure comprising a base or platform, and a vertical wall. In order that stability may be ensured, the construction of such walls requires very careful consideration, and they should be designed so that resistance to overturning is provided for, either by forming a battering face or by the provision of counterforts or buttresses at frequent intervals along the length of the walls.

These counterforts will divide the vertical wall into a series of panels which will be supported along three edges. Such provision is necessary because reinforced concrete retaining walls are light in weight compared with those constructed of mass concrete.

When reinforced concrete retaining walls are built independent of the superstructure they should be provided with a vertical projection or heel, which will greatly assist in securing the stability of the wall by resisting the sliding tendency. In building such walls it is advisable to provide expansion joints about every 30 ft. in the length of the wall.

Reinforced concrete retaining walls are often designed to form part of, and

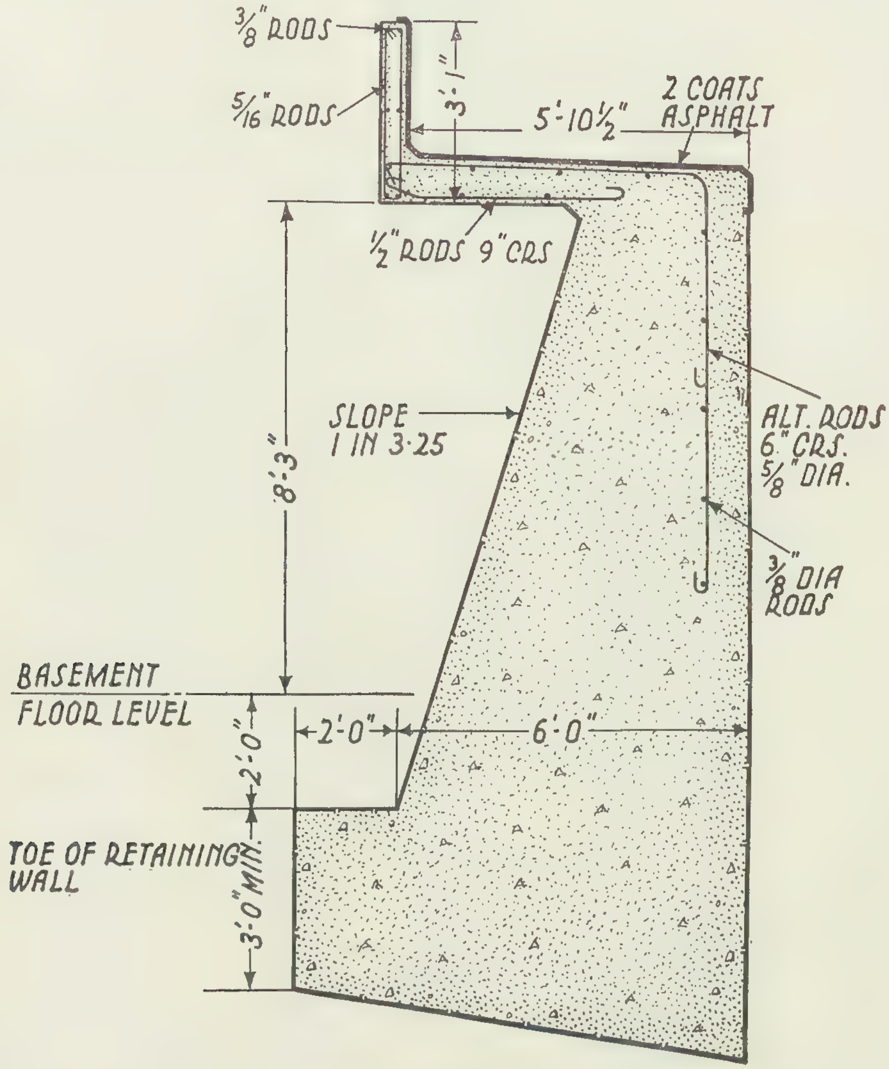

Fig. 20. Mass Concrete Retaining Wall

in conjunction with, the concrete foundations of the building, whose weight materially assists in securing stability.

Fig. 21 shows a stanchion base and steel grillage resting on the top portion of a reinforced concrete retaining wall. In this example the retaining wall is designed to act as the concrete foundation for a superstructure which includes provision for a single basement floor. A section through another reinforced concrete retaining wall for a single basement floor is given in Fig. 22. In this instance the base of the external stanchions rests upon the toe of the retaining wall.

Retaining Walls for Multiple Basement Floors. Retaining walls for

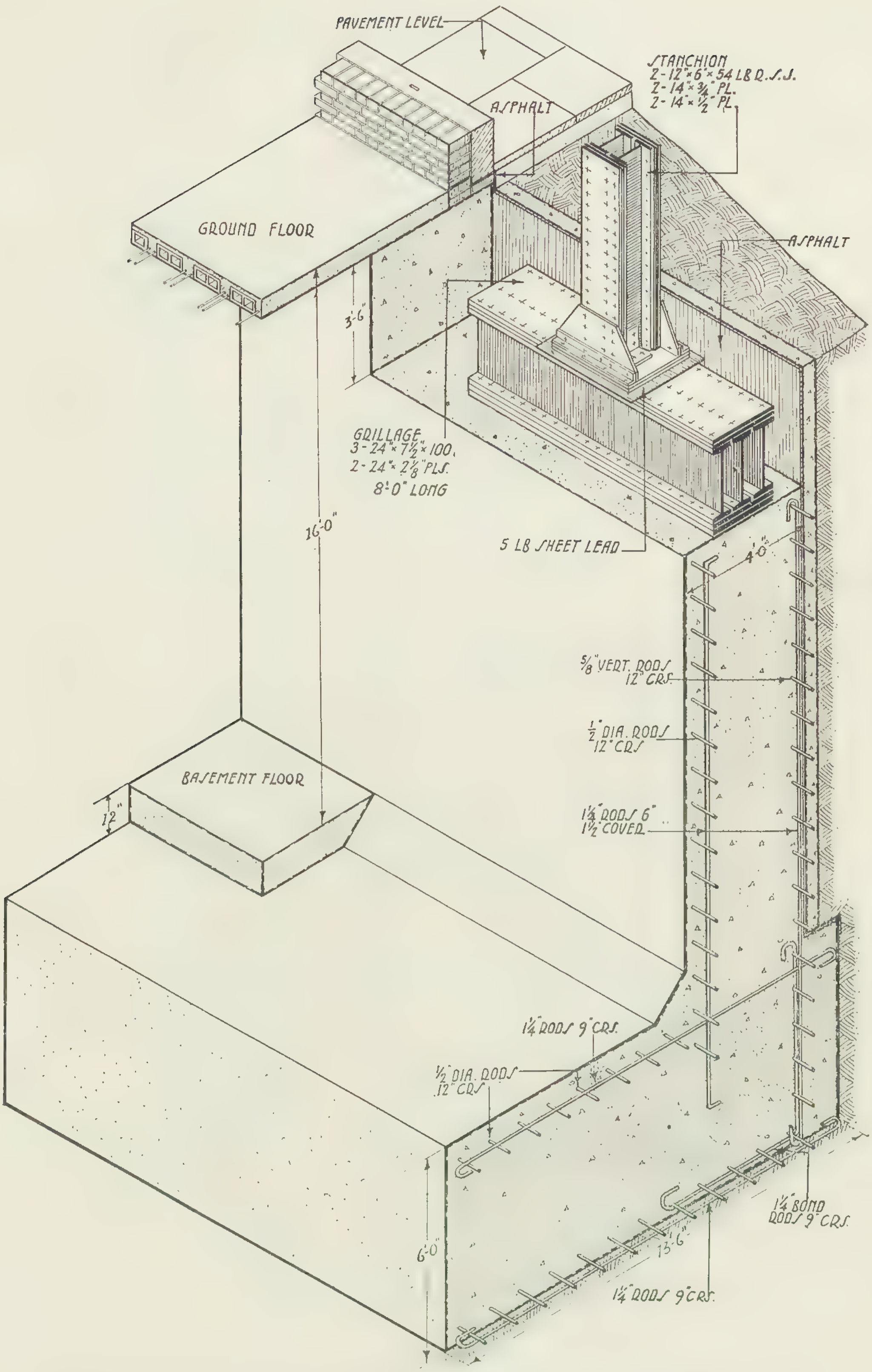

FIG. 21. REINFORCED CONCRETE RETAINING WALL SUPPORTING STEEL STANCHION

deep excavations, and where there are multiple basement floors, are often designed with battering faces formed in a series of offsets at about floor levels. These offsets provide for the support of the concrete floors or for their steelwork.

A section through a reinforced concrete retaining wall with offsets at floor levels is given in Fig. 23. The base of the external stanchions rests upon the toe

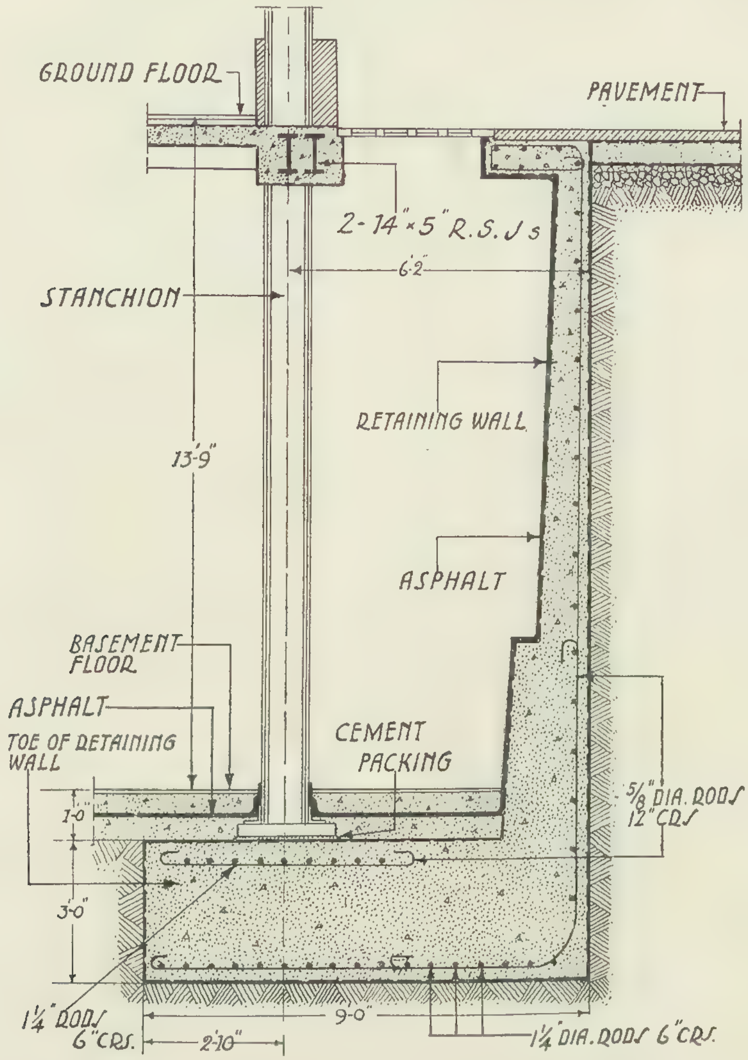

Fig. 22. Reinforced Concrete Retaining Wall

of the retaining wall, which is designed as a concrete foundation for the support of the concentrated loads which are transmitted from the stanchions.

Another type of reinforced concrete retaining wall specially designed for deep excavations and multiple basement floors is shown in Fig. 24. In this case the battering face of the wall is provided with a deep offset midway in the height of the retaining wall. This offset forms the seating for the steel grillage bases of the external stanchions. The weight of the external walls and the loads of the superstructure are transmitted to, and supported upon, the foot of the retaining wall. This method of construction is specially suited to positions where confined site boundaries preclude the setting back of the stanchions so that their bases can rest direct upon the toe of the retaining wall.

Another form of retaining wall is shown in section in Fig. 25. The retaining

wall in this instance is a vertical brick wall in which steel stanchions are embedded. These steel stanchions are situated at intervals along its length so that they coincide with the centre line of the stanchions of the superstructure. The

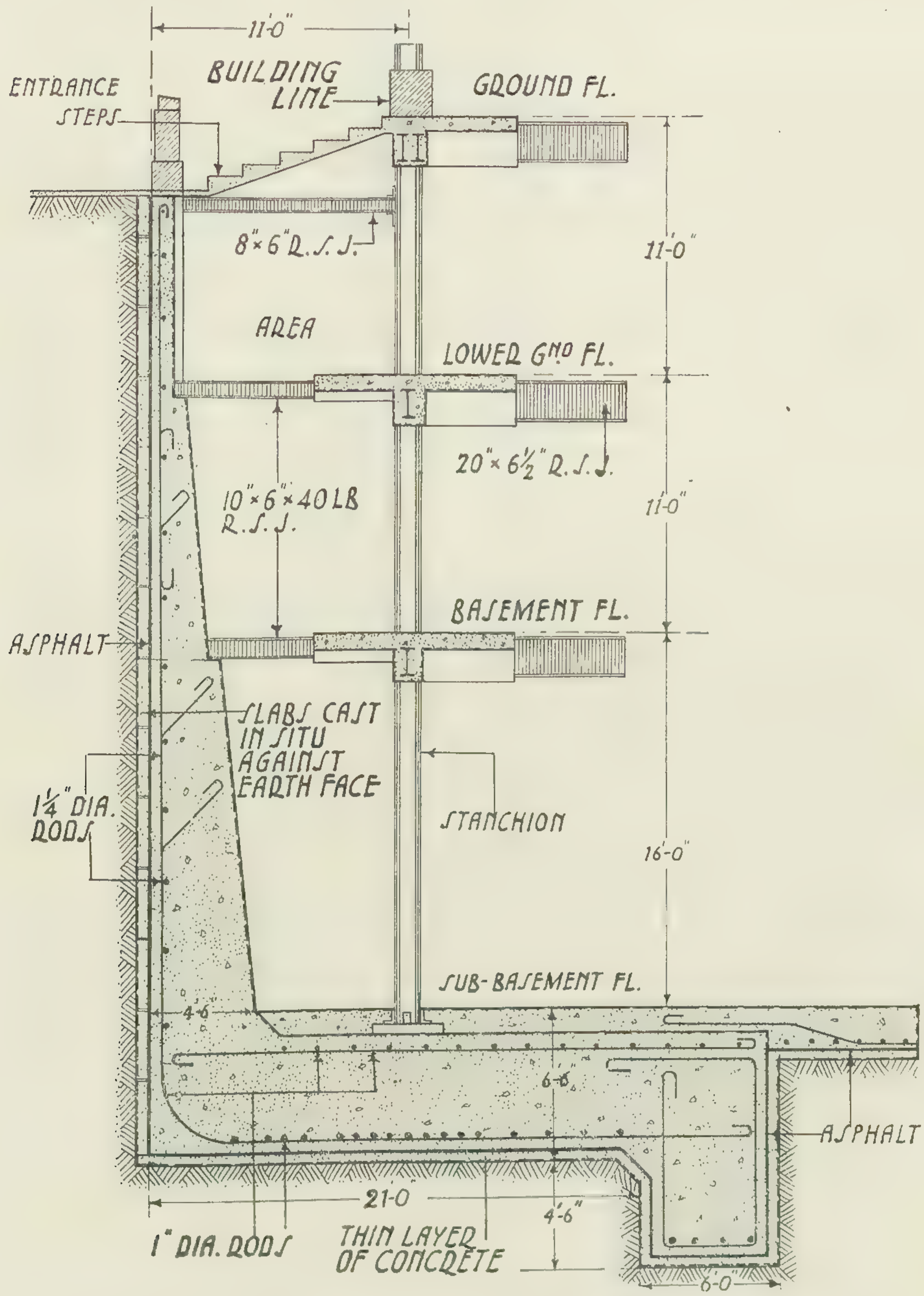

FIG. 23. REINFORCED CONCRETE RETAINING WALL FOR MULTIPLE BASEMENT FLOORS
Showing stanchion base resting on toe of retaining wall.

toe of the retaining wall is formed in reinforced concrete and is designed to act as a concrete foundation for the steel stanchions, and also as an abutment for temporary rakers. The rakers would be removed after the erection of the steelwork of the superstructure is complete.

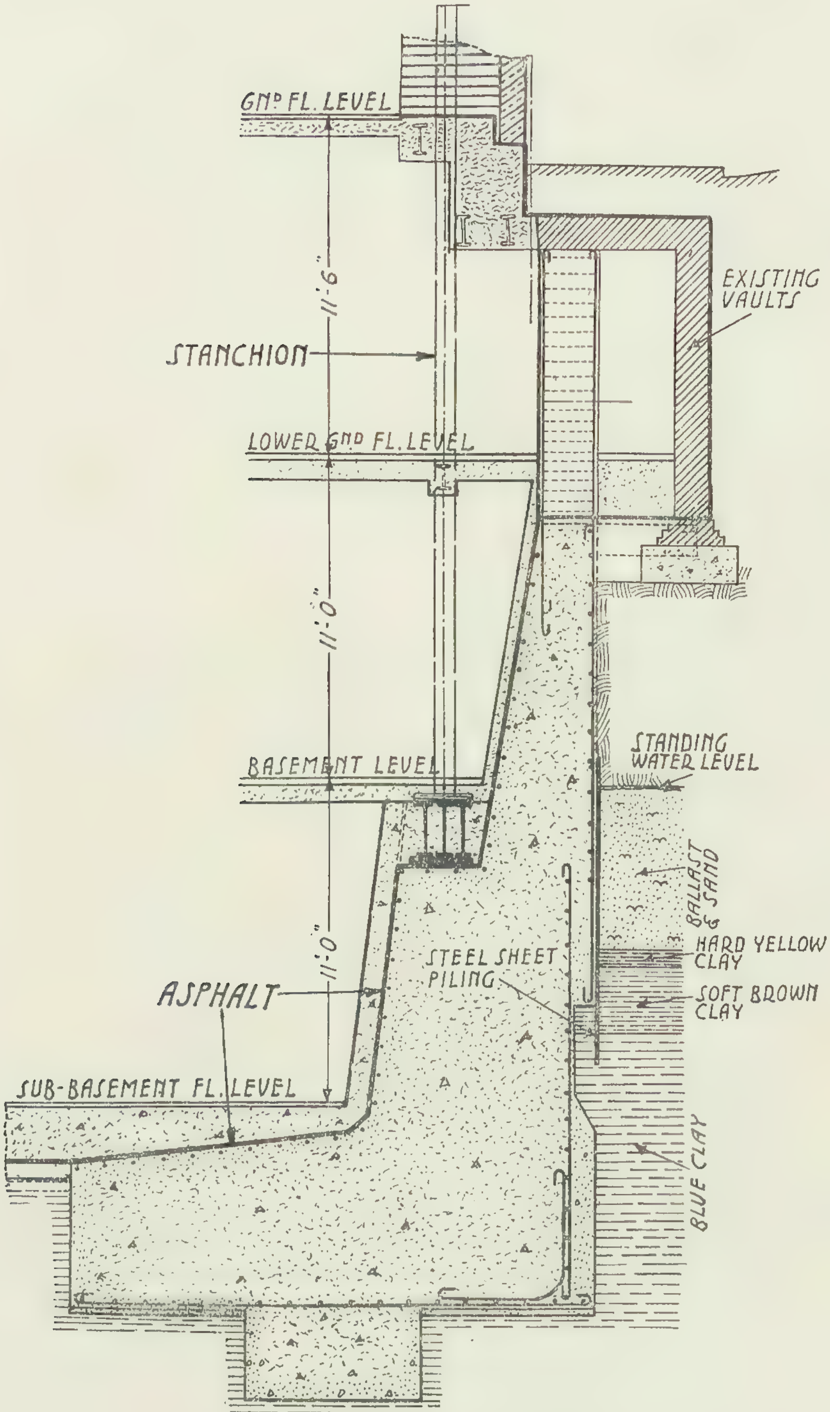

FIG. 24. REINFORCED CONCRETE RETAINING WALL FOR MULTIPLE BASEMENT FLOORS
Showing stanchion base resting on recessed portion of retaining wall.

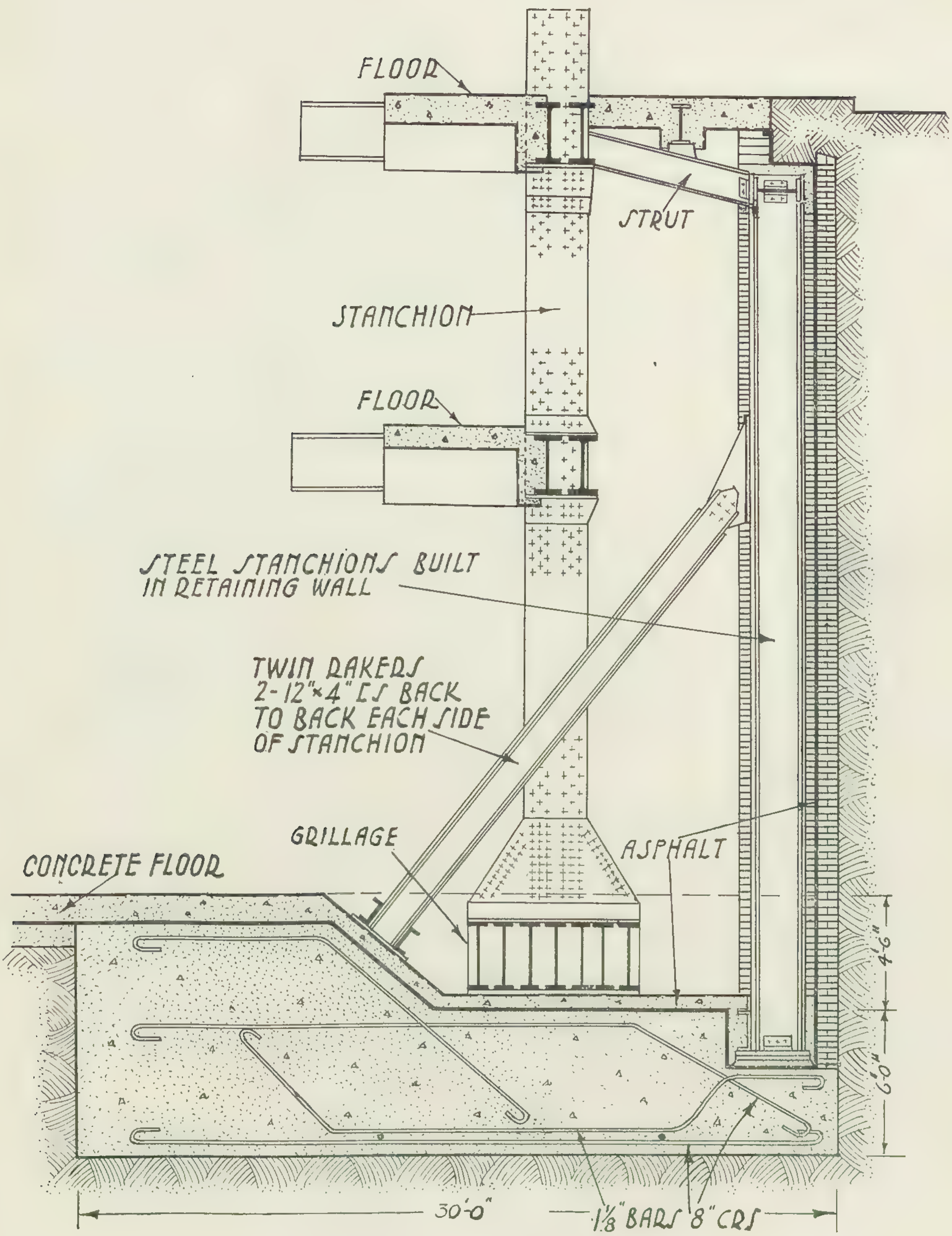

FIG. 25. BRICK AND STEEL RETAINING WALL

Before the rakers are removed, short steel struts are placed between the tops of the vertical steel stanchions. These are embedded in the retaining wall and connected to the steel frame of the superstructure.

The position of these struts not only ensures the stability of the retaining

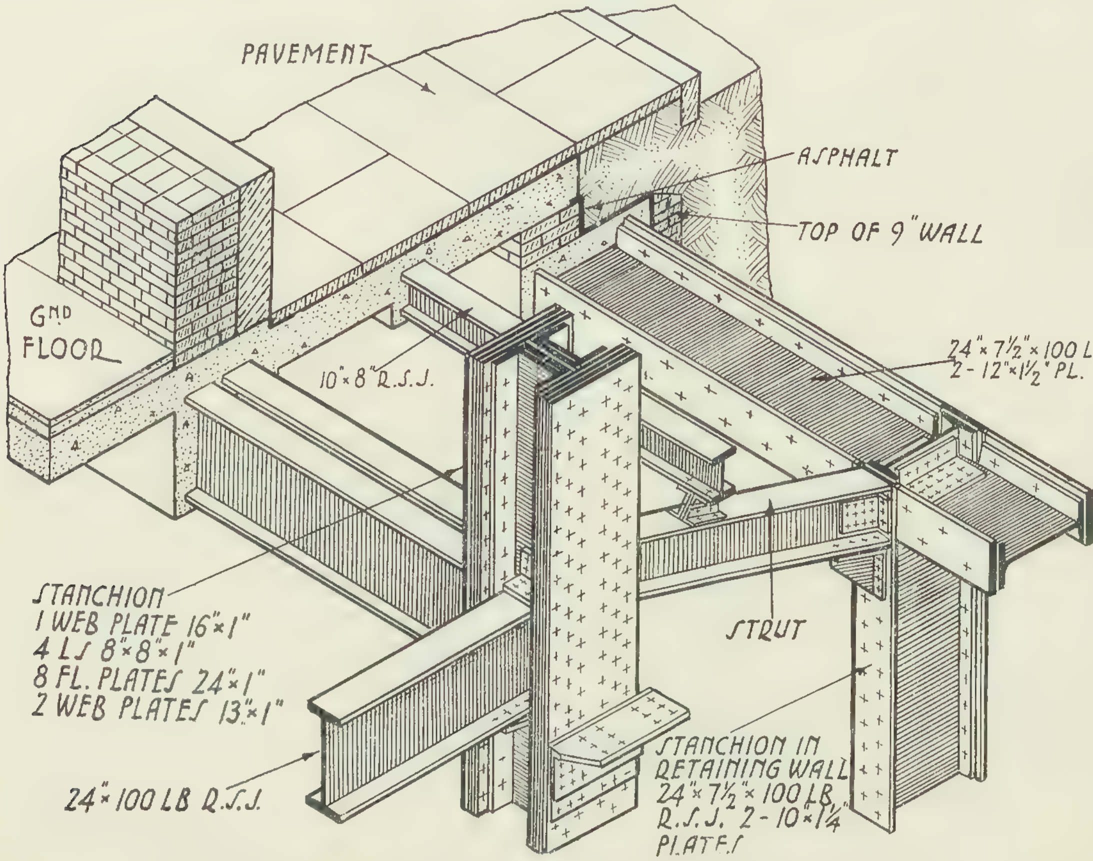

Fig. 26. Construction of Retaining Wall at Pavement Level

wall but also forms a means of support to the concrete slab which forms the base to the pavement.

A sketch showing the construction at pavement level and the position of the steel struts is given in Fig. 26. These notes are not intended to outline the theoretical or practical design of retaining walls, but to supplement the illustrations which are given as typical examples of retaining wall construction. For information concerning the principles of design, the reader is recommended to study the various books on structural engineering.

CHAPTER III

CONSTRUCTION OF WALLS

The construction and thickness of walls will vary according to the type of structure to be erected. Walls which are built to carry the loads of the floors and roofs should be thicker than walls which are intended merely as the wrapping or the clothing to the skeleton of structures.

Thickness of Walls. The following are extracts from the Second Schedule, Part 2, Sections 1 and 2 of the London Building Act, 1930, concerning the thickness of walls, and which applies to load-carrying walls.

"For buildings, not being public buildings or buildings of the warehouse class, where the wall does not exceed 25 ft. in height, its thickness shall be as follows—

"If the wall does not exceed 30 ft. in length, and does not comprise more than two stories, it shall be $8\frac{1}{2}$ in. thick for the whole of its height.

"If the wall exceeds 30 ft. in length or comprises more than two stories it shall be 13 in. thick below the topmost story and $8\frac{1}{2}$ in. thick for the rest of its height."

Under Part 3 of the Second Schedule of the above Act, external walls of buildings of the warehouse class must not be less than 13 in. thick throughout their height.

From the foregoing it will be noticed that the thickness of the walls depends very largely upon practical requirements and circumstances.

An isolated wall and one that is required to withstand lateral pressure should be of greater thickness than an external wall of a building, even though the latter has to carry the loads of the floors and roof.

Enclosing and Panel Walls. With the advent of steel and reinforced concrete framed structures, walls are no longer required to support the loads of the building, as these are borne by the framework of the structure.

When walls are built in conjunction with framed structures they should act as an external wrapping round the framework and form an impervious skin to the weather. Such walls should satisfy the following requirements—

(1) They must be impervious to the weather. This can be effected by facing the wall with an impervious material, or by forming a cavity in the thickness of the wall.

(2) They must be lined with a pervious skin on the inside to absorb the condensation, and preferably one that will absorb or prevent the transmission of sound.

(3) They must be strong enough to withstand any external shocks, such as wind pressure.

Brick Walls. The strength and appearance of brick walls will depend very largely upon the arrangement of the bricks as laid to form the wall.

Bond. The arrangement of the bricks in the wall is known as *bond.* There are several recognized types of *bond*, but the two principal ones are *English bond* and *Flemish bond*, although there are variations of these two kinds.

Bricks should be placed in a wall so that the vertical joints between those in one course are covered by the vertical joints in the course adjacent, above and below, thus avoiding continuous vertical joints.

Bond is dependent upon the relative dimensions of the bricks, therefore bricks are made of standard sizes. During recent years an arrangement has been made between the Royal Institute of British Architects and the leading brick manufacturers whereby standard maximum and minimum sizes for bricks have been adopted, but in some northern counties the agreement allows for a slight variation in the heights of the bricks.

English bond consists of alternate courses of headers and stretchers.

Flemish bond consists of alternate headers and stretchers in the same course.

English bond is apparently stronger than Flemish bond because of the entire exclusion of continuous vertical joints, whereas Flemish bond occasions an *internal* continuous joint.

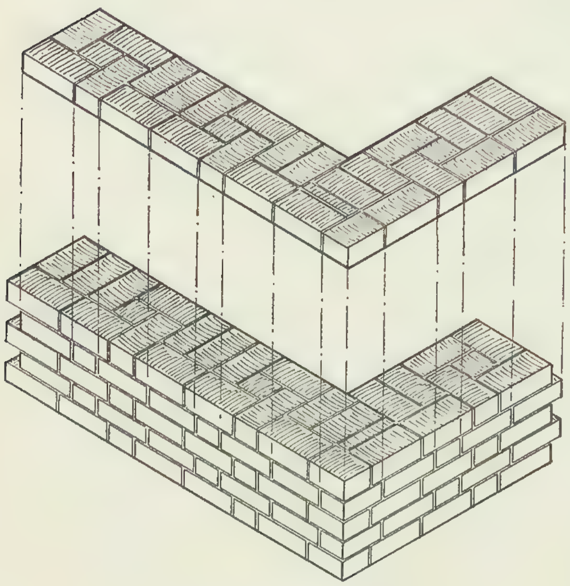

Fig. 27. Brick Bonding with $\frac{3}{4}$ in. Quoin Bricks

Whether this is a serious weakness involves the question of the importance of correct bond in modern practice. There is no doubt as to the importance of this matter where the walls are intended to carry the loads of the building and when the bricks for such walls are bedded and jointed in ordinary lime mortar. But with the advent of Portland cement and special hydrated lime mortars correct bond is not essential. Further, because of the changed methods of wall construction, bond in brickwork does not play such an important part in the making of panel walls which enclose framed structures, whether of steel or concrete. Under these conditions appearance is of more importance than bond.

One result of these changes in wall construction is that the fundamental principles of correct bonding in brick work are often disregarded and more or less fanciful face treatment, or arrangement of facing bricks, is adopted.

Fig. 27 shows the arrangement of bricks at an angle of a wall which dispenses with the usual $2\frac{1}{4}$ in. closers next to the quoin headers. Two stretchers and then a header are placed side by side in each course. Such an arrangement produces a very pleasing effect and is very suitable when using thin facing bricks. The quoin bricks are three-quarter bricks.

Flemish bond is supposed to have a better appearance than English bond. Its chief advantage, however, is that it is more economical when using expensive facing bricks. It may be used also in the construction of cavity walls. In 9 in. walls fair faces can be obtained more readily in Flemish bond than in English bond.

English garden-wall bond. English garden-wall bond consists of one course of headers to three or five courses of stretchers.

Heading bond. This is used chiefly in footings or for walls having sharp curves. When used for the latter the bricks should be snapped.

Cavity Walls. To prevent the penetration of dampness through external walls to the interior of a building, a cavity or air space may be formed in the

thickness of the wall. The provision of this cavity is especially recommended if the face of the wall is exposed to driving rains. When forming a cavity it is usual to build a $4\frac{1}{2}$ in. external wall or skin, and a $4\frac{1}{2}$ in. or 9 in. internal wall.

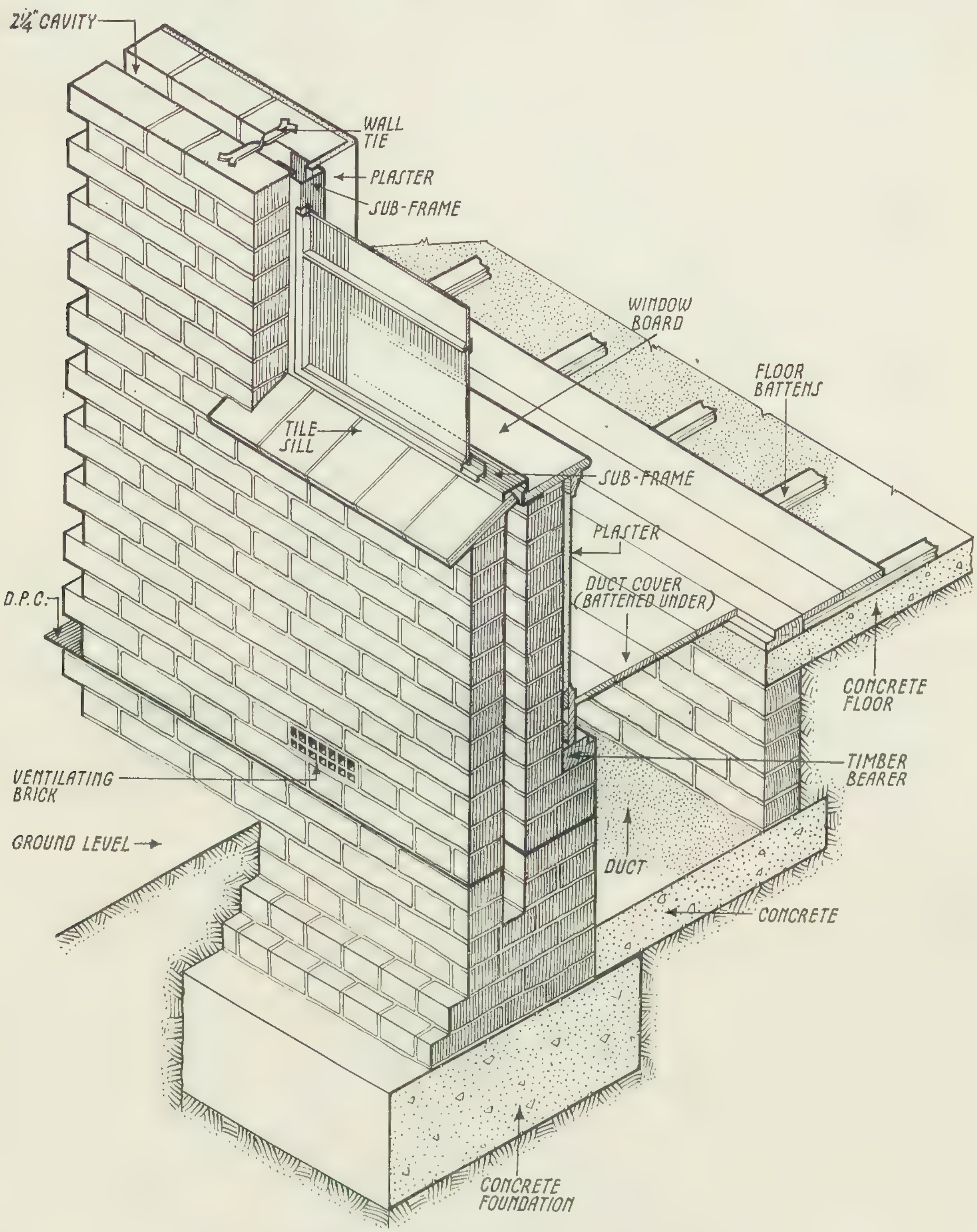

FIG. 28. CONSTRUCTION AT THE BASE OF A BRICK CAVITY WALL

If the loads are to be carried by the internal skin it may be advisable to increase its thickness so that it will safely carry them.

The external skin of such walls may be built in English, Flemish, or either of garden-wall bonds, snap headers being used in each case.

Stretcher bond can also be adopted, but the resulting appearance is not so pleasing unless a definite feature is made of the horizontal bed joints by using a distinctive pointing material.

Fig. 28 is a detail of a brick cavity wall showing the construction at the ground

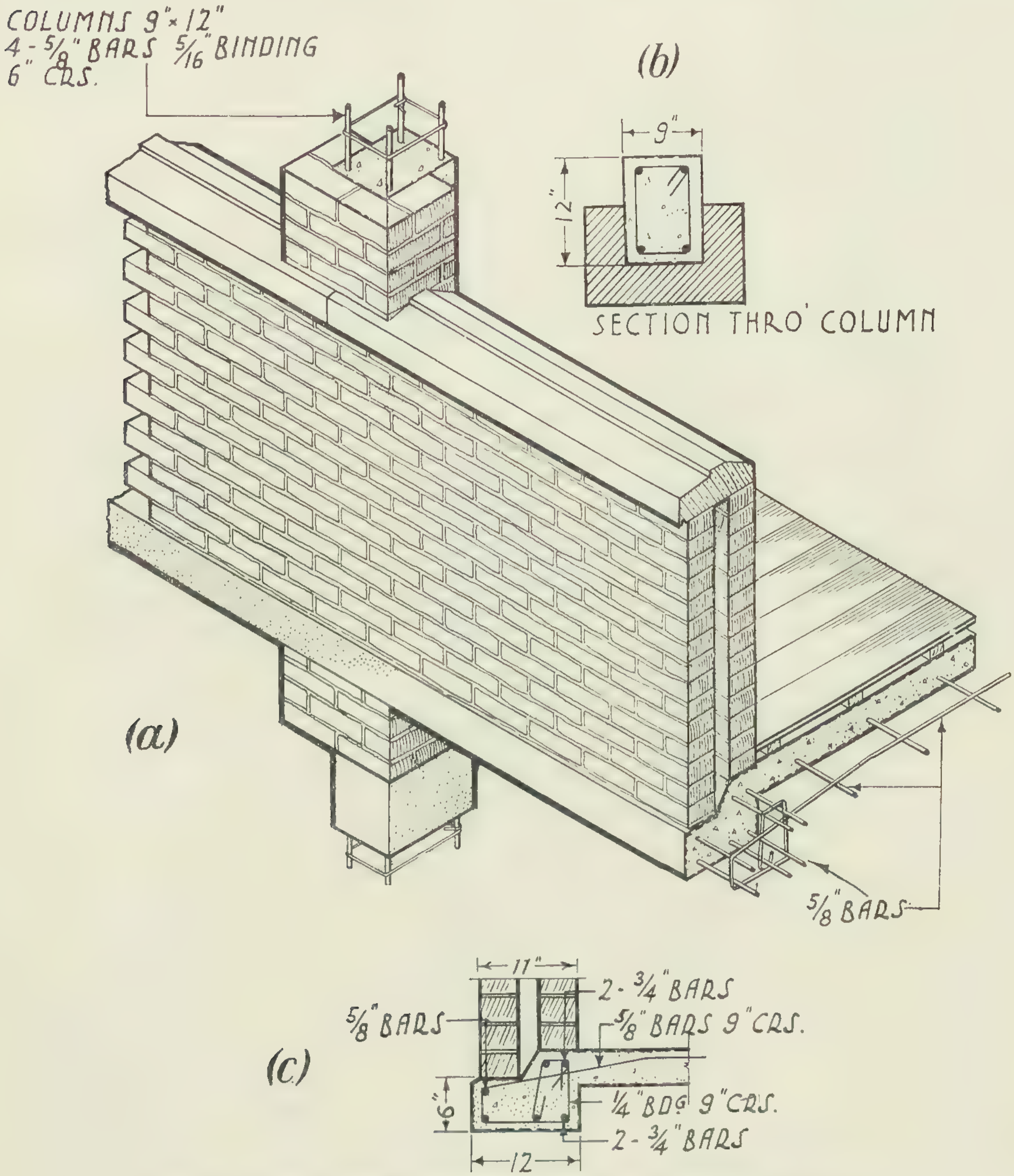

Fig. 29. Brick Cavity Wall Supported upon Concrete Floors

(a) Construction at floor level.
(b) Section through reinforced concrete column.
(c) Section through reinforced concrete projection.

floor level, including a duct under the floor. The construction at the base of the window opening is also shown. Floor ducts are often necessary for housing the various service and heating pipes.

Figs. 29 (*a*), 29 (*b*), and 29 (*c*) show the construction of a brick cavity wall which is supported on the structural members at floor level.

This type of wall is known as a *panel wall* and forms the clothing of a reinforced concrete-framed structure. When building cavity walls care must be exercised in keeping the cavity clear from mortar droppings, because the existence of such material in it will form a bridge for the transference of moisture to the internal wall. Ventilation of the cavity is essential and may be obtained by the provision of air bricks, which should be built in the upper and lower parts of the external wall. If the ground floor is to be constructed of timber, air bricks should be built in the internal wall just below floor level. The rigidity of a cavity

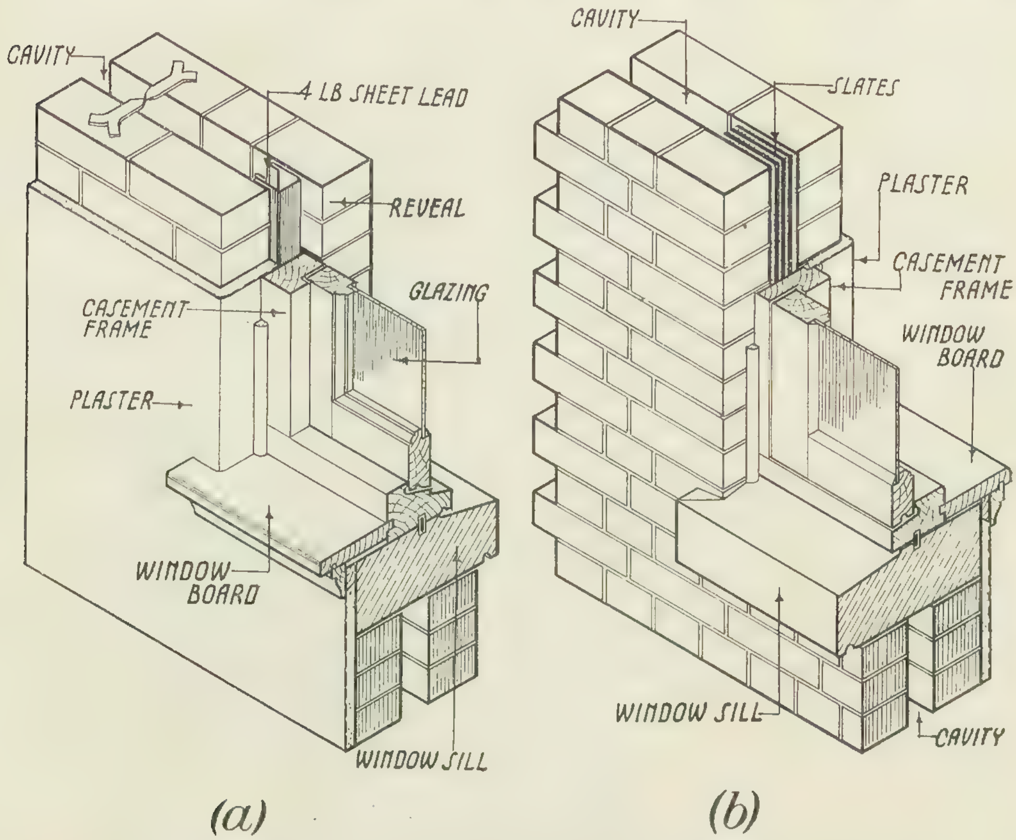

FIG. 30. CONSTRUCTION OF BRICK CAVITY WALLS AT SIDES OF OPENINGS

(*a*) Sheet lead strip covering cavity.
(*b*) Cavity bridged with slates in cement.

wall should be assisted by placing *wall ties* across the cavity at frequent intervals throughout the length and height of the wall. These ties should be designed and fixed so that any moisture which may penetrate the outer wall will not travel along the ties to the surface of the inner wall.

Construction at Openings. Special construction is necessary at the sides of window and door openings in cavity walls. These are vital points in cavity wall construction as dampness, due to driving rains, is very liable to pass through to the inner wall at its junction with the door or window frame. Many methods have been adopted to prevent failure at these vital points. In some instances the cavity at the sides of the opening is filled with bricks and mortar. This method converts the cavity wall into a solid wall at these points and moisture will creep along the bricks to the inside wall. A better method is shown in Fig. 30 (*b*). In this example vertical slates are placed in the cavity instead of

bricks, but the same weakness exists. Fig. 30 (*a*) shows a strip of sheet lead inserted in the cavity, but very little benefit will be derived by its inclusion.

An improvement upon the foregoing methods is to be seen in Fig. 28, which illustrates the construction through the jamb of a window opening in a cavity wall fitted with a metal frame specially designed for this purpose by Messrs. Henry Hope & Sons. It will be readily seen that there is very little likelihood of dampness creeping around the frame and penetrating to the inner wall.

Composite Walls. The walls of many important buildings are faced with

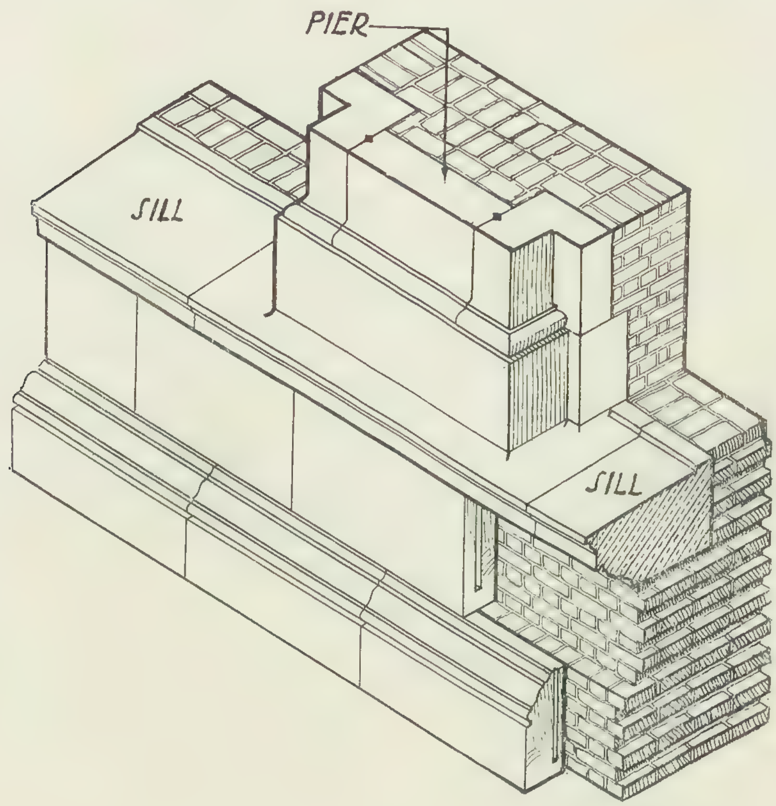

Fig. 31. Composite Stone-faced Wall with Brick Backing

stone in preference to brick. At one time such walls were built entirely of stone throughout their thickness. Wrought stone was used as the facing material and rough hewn stone or rubble as the material comprising the mass of the wall.

For many years it has been the custom to build walls with brick and face them with wrought stone, and such walls are known as *composite walls*.

The heights of the stone courses should be arranged so as to coincide with the total height of several brick courses, as this will allow for good bonding with the brickwork. A composite stone-faced wall is shown in Fig. 31. This method of construction is very suitable for walls which are required to carry heavy loads but quite unnecessary when walls are built in conjunction with framed structures.

An illustration of the usual method adopted for the bonding and construction of stone-faced walls, when built in conjunction with a steel-framed structure, is given in Fig. 32. It will be noticed that the stone courses bond into the brickwork in the manner adopted when walls have to carry the loads of the building. There appears to be no necessity for this bonding, and a great amount of expense is often incurred in notching the stones to fit the structural members, or the concrete

casing to such structural members. A more suitable method appears to be to cover walls with slabs of facing material, and the result is good when the slabs are adequately secured to the wall, as shown in Fig. 33.

Reconstructed stone is now used very widely as a facing material. The procedure in construction is the same as when using natural stone facings.

Fig. 34 shows a portion of a wall faced with a combination of reconstructed stone and brickwork and is typical of the manner in which walls are built in conjunction with framed structures.

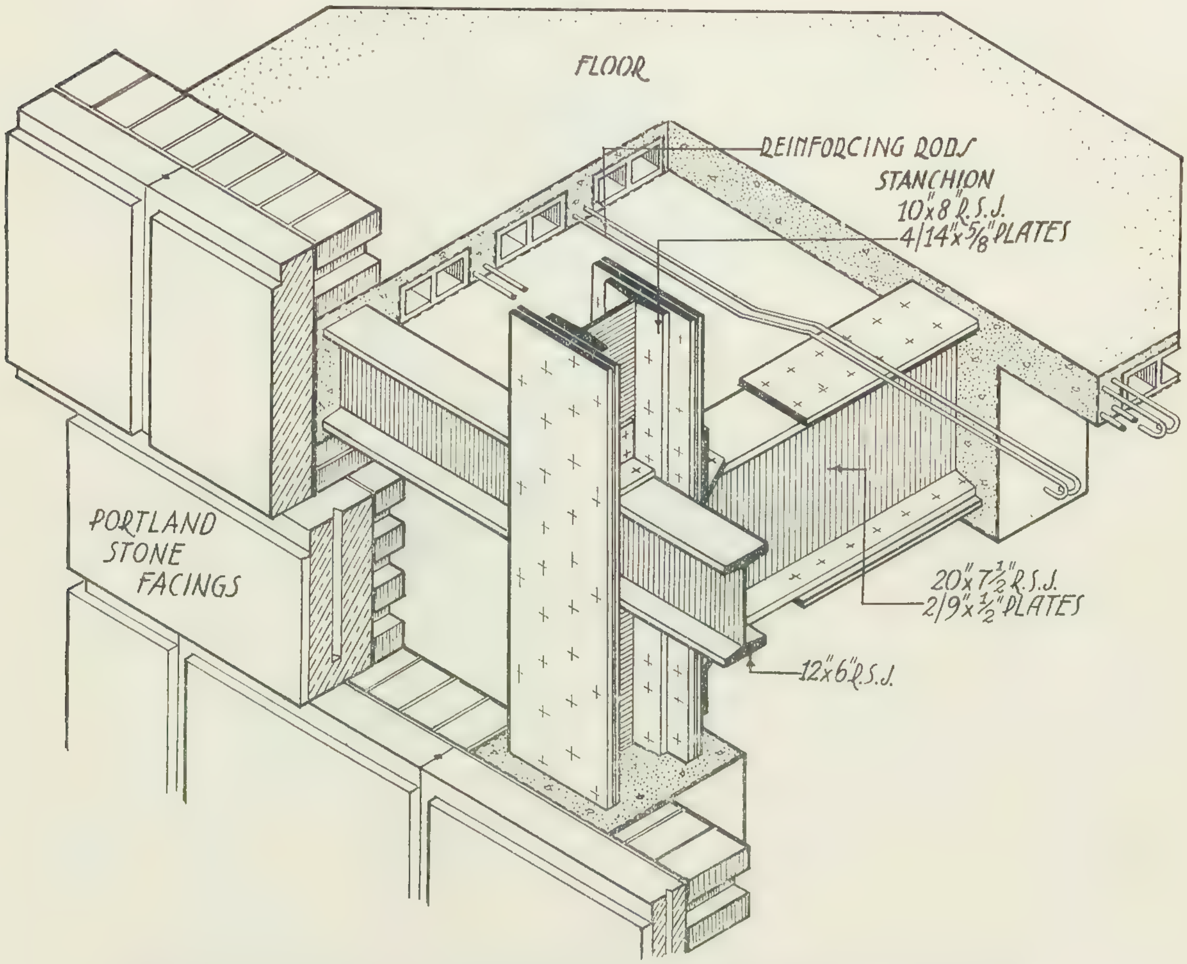

Fig. 32. Stone-faced Wall in Conjunction with a Steel-framed Structure

Terracotta and faience facings were used very considerably a few years ago, but their use does not appear to be so general at the present time. This decline is due very largely to the elimination of a profusion of ornament in modern architecture, as repeating ornament could of course be reproduced in terracotta much more cheaply than it can be executed in stone.

Faience is a very suitable material for facing walls of framed structures. With the more general use of colours as an architectural ornament, faience is likely to be used to a greater extent than heretofore.

Fig. 35 may be taken as typical of the construction often adopted for walls faced in terracotta or faience and spanning wide openings.

Walls Covering Framed Structures. The introduction of steel- and

concrete-framed structures has resulted in many changes in wall construction. When walls are built in conjunction with framed structures they should not be required to carry the loads, but to act merely as a medium for architectural expression, and for the purposes mentioned at the commencement of this chapter.

Timber Framing. Timber-framed and braced work may be said to be the forerunner of modern framed structures, and many points in its favour can be urged for its use in buildings of a semi-permanent character. The external walls

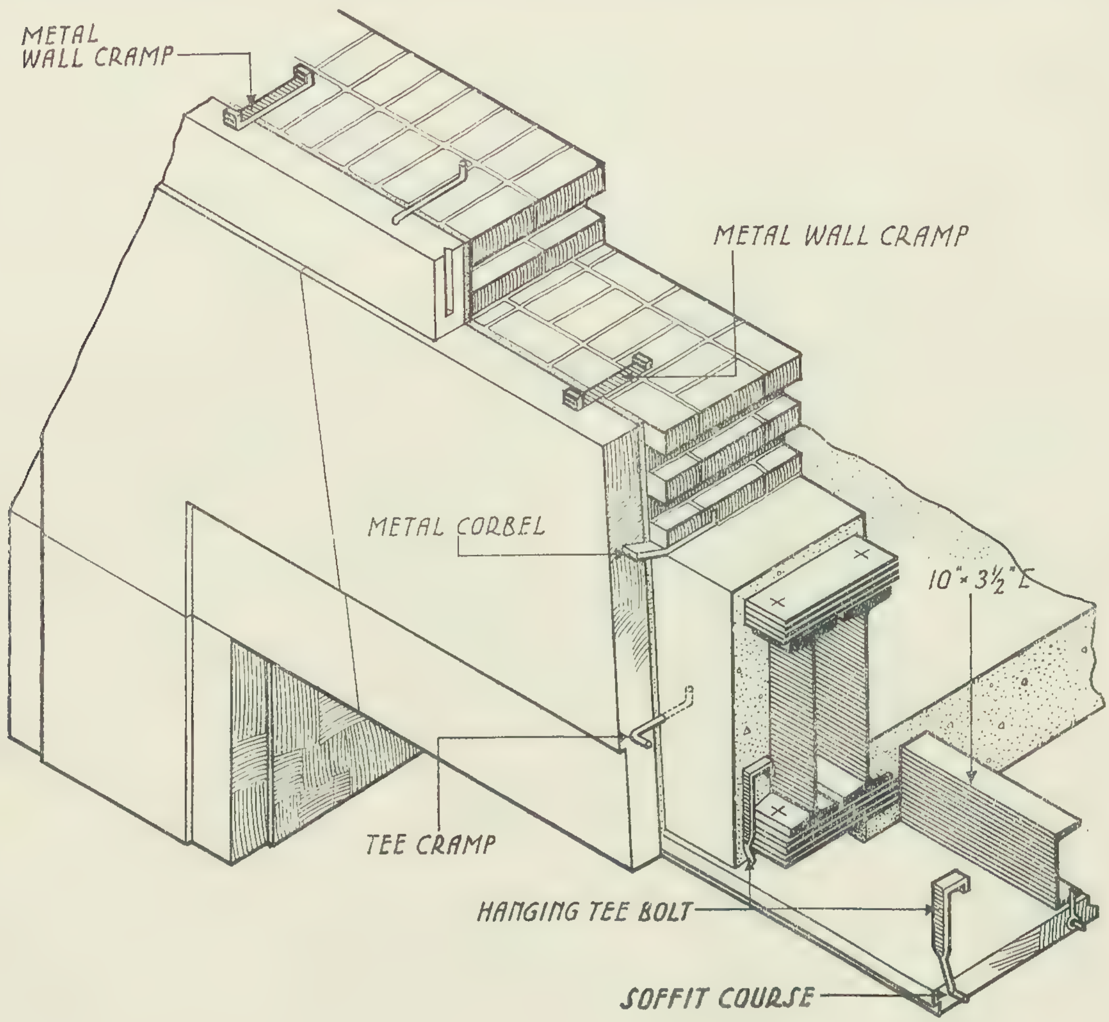

Fig. 33. Brick Wall Faced with Stone Slabs

may be weather-boarded on the outside, while the internal wall surface can be formed by the application of one of the many kinds of pressed fibre wall boarding, and rendered insulative by the application of proper materials. Details showing the construction at the base and ground floor level of a timber-framed structure are given in Figs. 36 and 37, which show the concrete foundations and alternative methods for constructing the ground floor.

In the latter example the brick base for the timber framing is shown faced with cement stucco, which forms a plinth around the building. This aids the prevention of dampness, due to splashings, and its penetration to the base of the wall.

In Fig. 36 the timber framing commences from and rests upon the top of the timber floor joists.

As an alternative to the weather boarding for the external wall finish, cement stucco may be applied by first nailing pressed fibre boards to the timber framing, and then covering the boarding with metal lathing which will form the key for the cement stucco facing. An example of this construction is shown in Fig. 38.

Construction of Walls at Floor Levels. As walls which clothe steel- or concrete-framed structures should depend upon the framework for their support, it is not necessary for them to be built from concrete foundations. They should be supported by the framework at the various floor levels, and the bonding of the stones arranged so that the courses at floor levels will rest upon the structural members, or upon a projection extended from the concrete floors. This method of construction will ensure that the walls enclosing each floor are structurally independent of the walls above or below. A sketch showing how this may be carried out is given in Fig. 39.

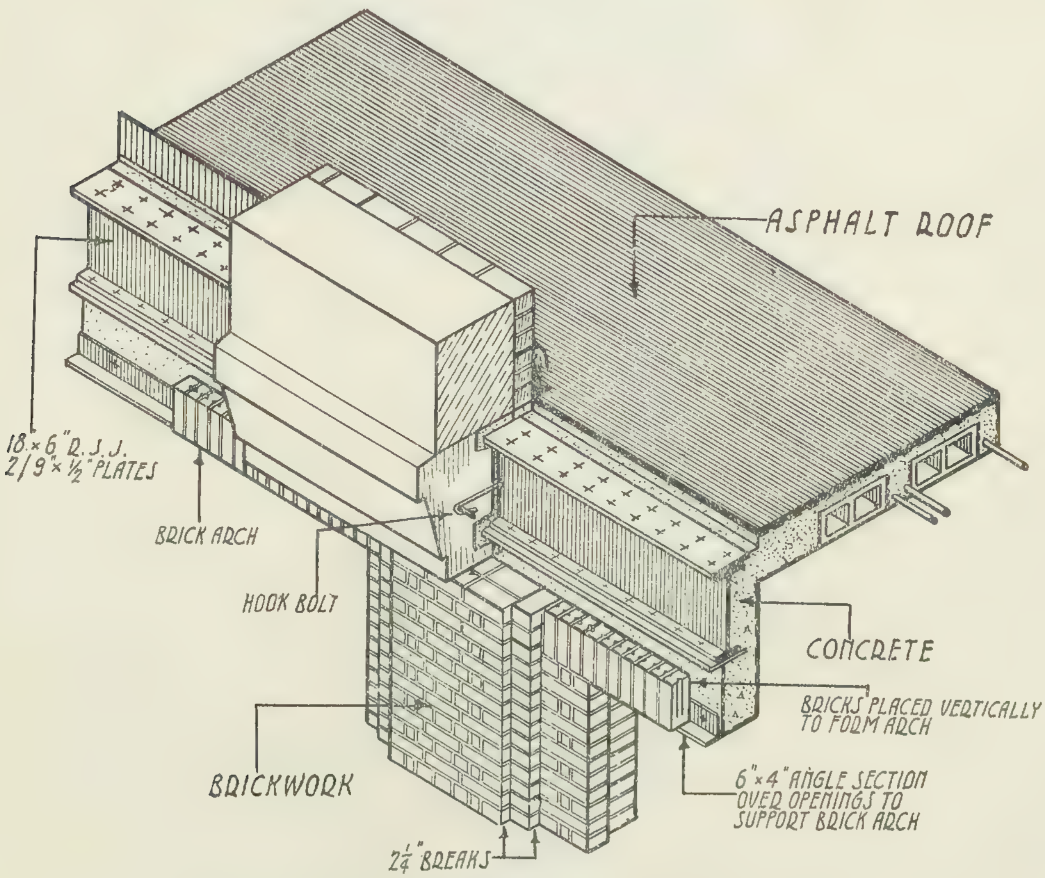

Fig. 34. Brick and Reconstructed Stone-faced Wall
Also construction of brick soldier arch.

It will be noticed that the stones composing the bottom course rest upon a concrete projection formed as a continuation of the floor slab.

Figs. 29 (*a*), 29 (*b*), and 29 (*c*) give details showing the construction of a brick cavity wall supported on a concrete projection, which is designed to form a horizontal band course and an external detail in the elevation.

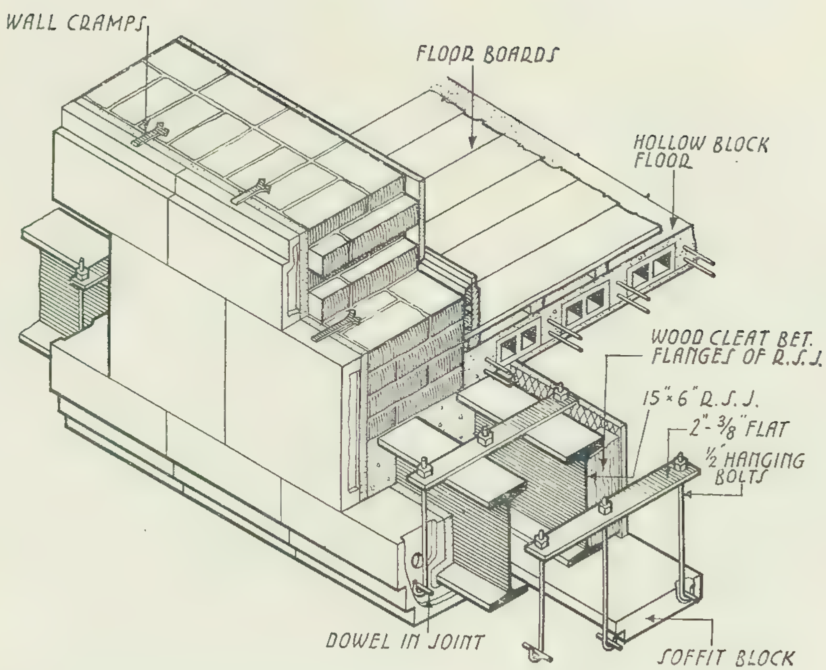

FIG. 35. TERRACOTTA FACINGS SUPPORTED UPON STEELWORK

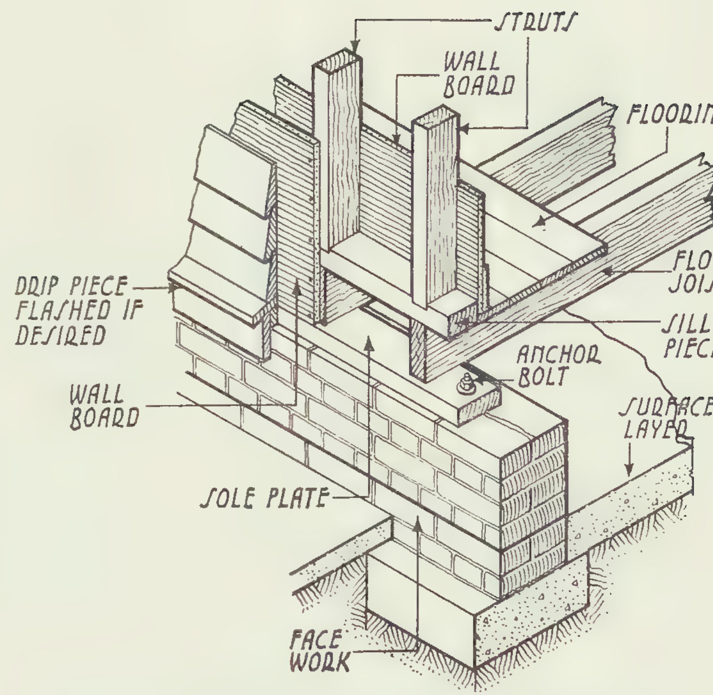

FIG. 36. TIMBER-FRAME CONSTRUCTION IN CONJUNCTION WITH A TIMBER GROUND FLOOR

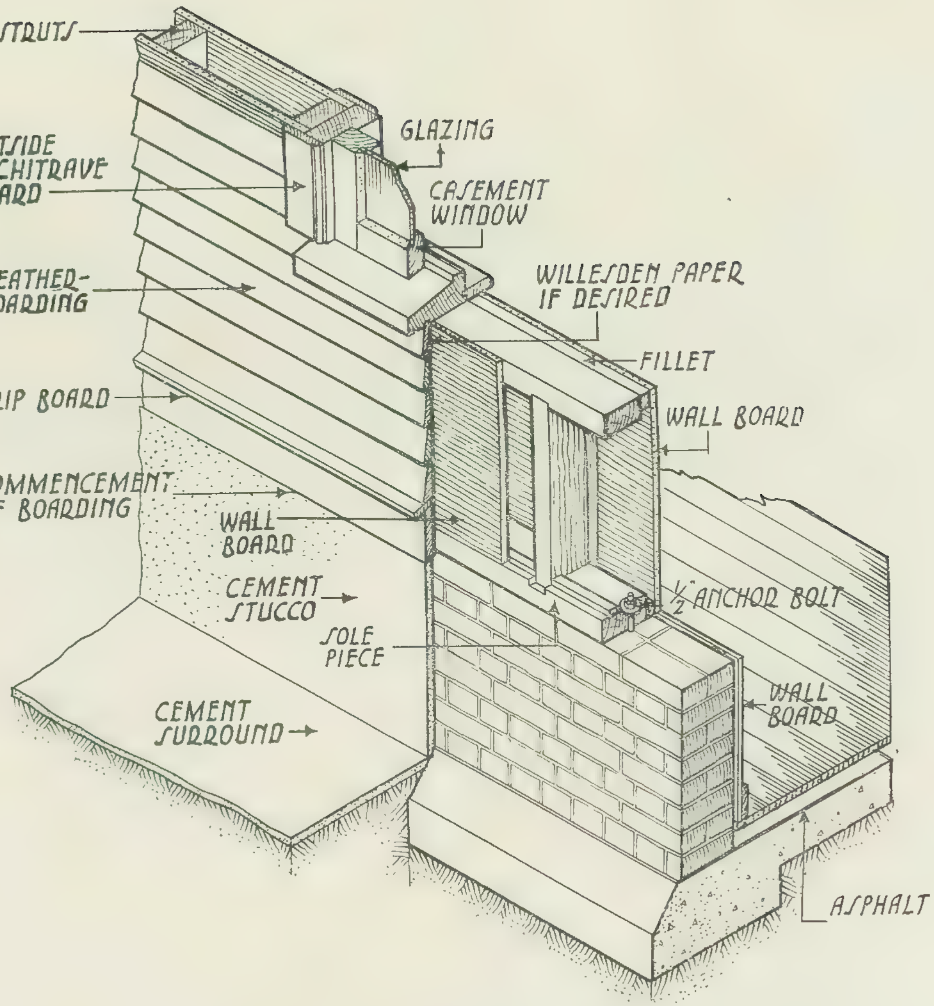

Fig. 37. Timber Frame Construction in Conjunction with a Concrete Ground Floor

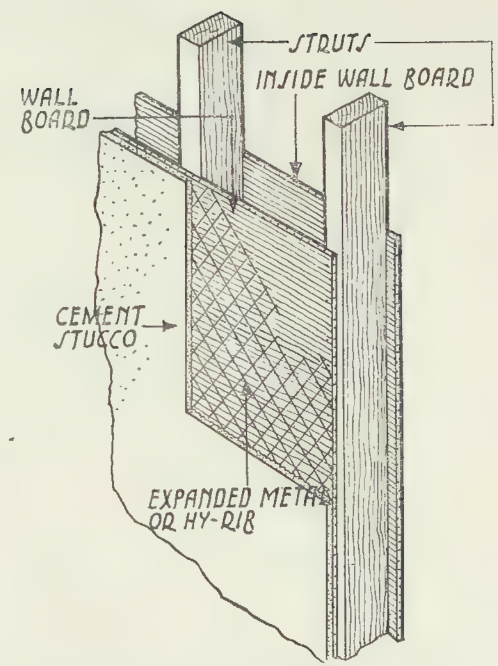

Fig. 38. Detail of External Finish to Timber Framing

Generally speaking, the external walls of steel- and concrete-framed structures commence about pavement level, and although they appear to be built up from the concrete foundations, they are usually supported on the structural members at ground level, as shown in Fig. 40. This detail includes the construction necessary for the support of the pavement and the gathering over for the support of the pavement lights. These are usually incorporated as a means of

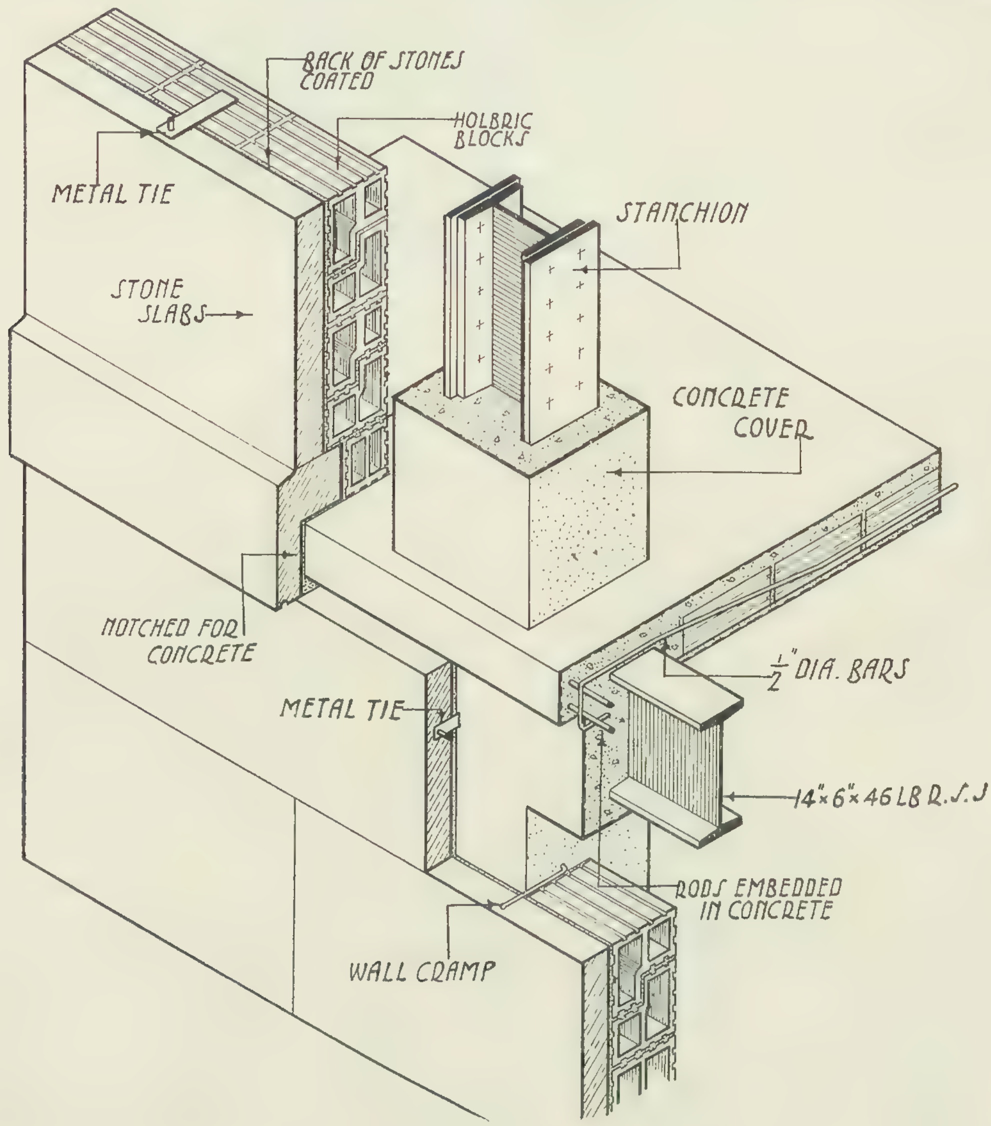

Fig. 39. Slab-faced Wall with Hollow Block Backing Supported upon Concrete at Floor Level

illumination for basement rooms in buildings facing main thoroughfares. If the site permits, an open area may be constructed so that vertical window openings may be formed in the elevation for lighting the basement rooms. In this case an open area should be constructed and the wall should commence at a lower level.

The construction of the base of the wall would now be similar to the preceding example.

If sub-basement floors are to be provided with natural light the pavement lights may be introduced in the floor surface of the open area.

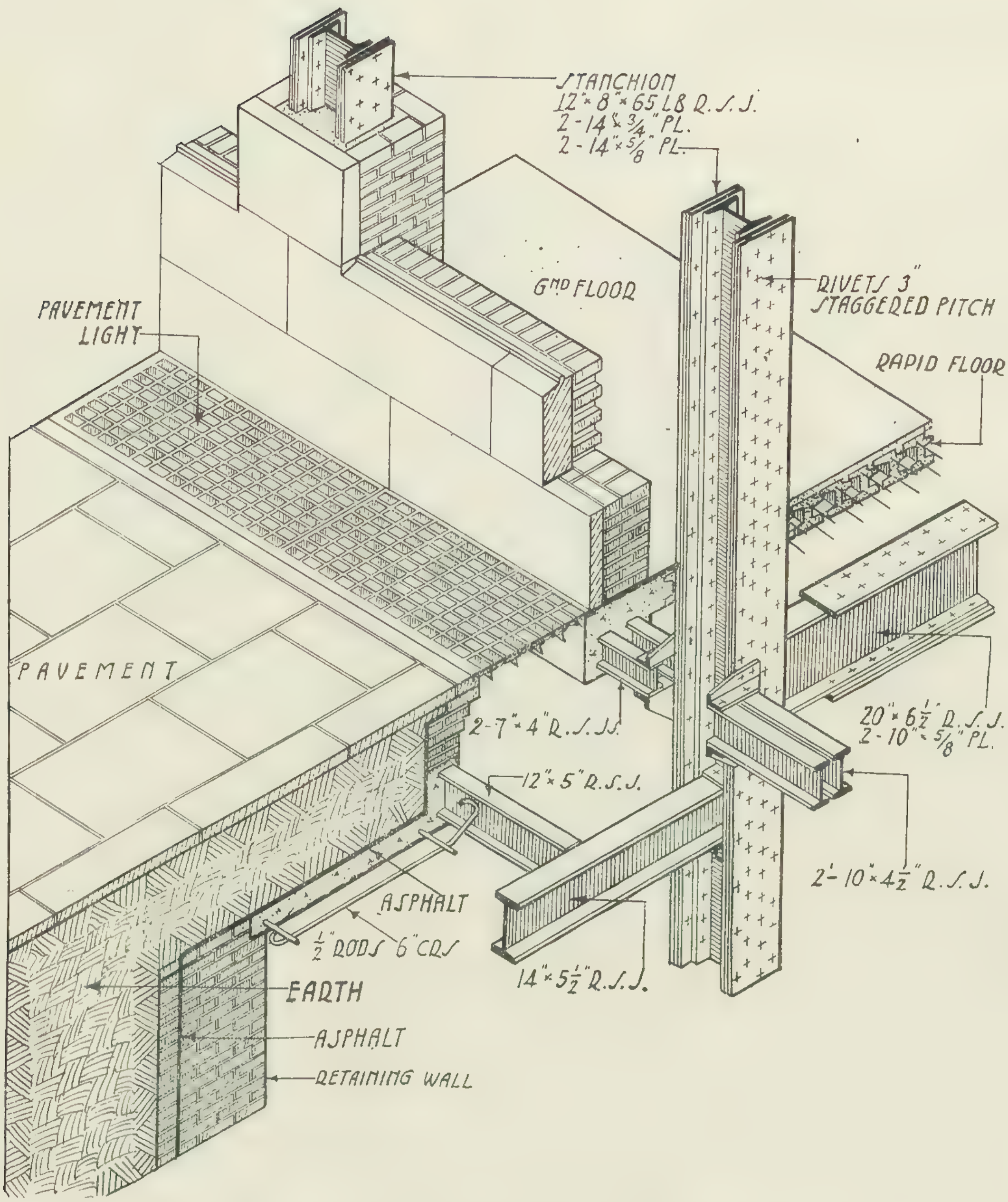

Fig. 40. Construction of External Walls at Ground Level Showing "Rapid" Floor

Fig. 41 shows the construction of a wall commencing at basement floor level, including that of the open area and top portion of the retaining wall.

Fig. 42 is a sketch detail through an open area wall showing the construction at this part of a wall when the basement window openings extend above the ground floor level so that the maximum amount of light may be admitted to the basement floor. The example also shows the area wall faced with white

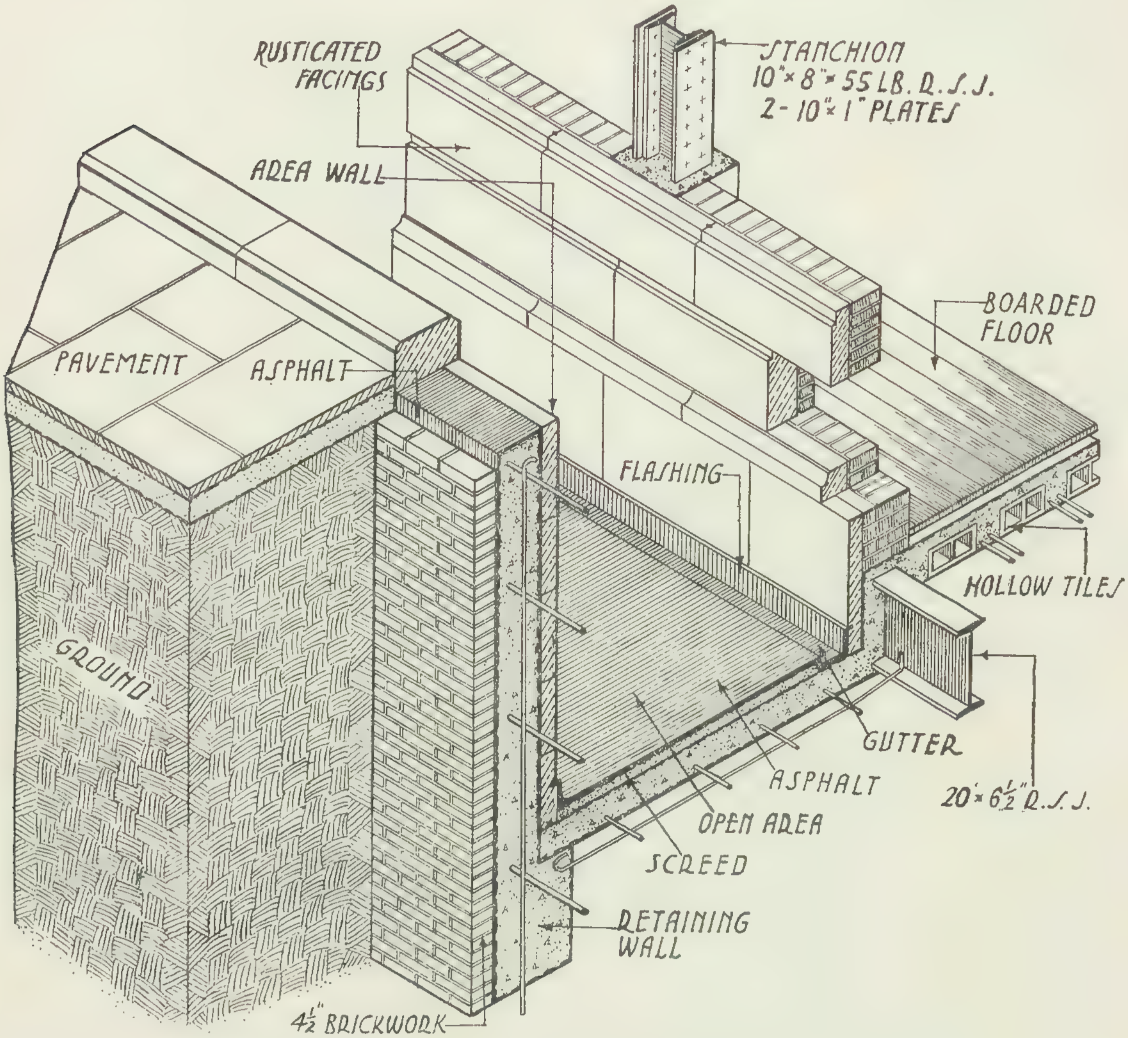

Fig. 41. Construction at Base of External Wall, Including the Construction of an Open Area

glazed tiles and the stonework commencing from the top of a concrete lintol course.

Modern Wall Construction

Veneered Walls. There is a difference between the older methods of wall construction and an ideal construction suited to modern needs.

A wall composed of two skins, an outer impervious skin to keep out the moisture, and an inner pervious skin to absorb the moisture given off by the occupants of the room, appears to approach the ideal in construction. Between these two skins may be, if desired, a filling of light concrete; or a cavity may be formed which will assist as an insulator to heat and sound.

When concrete is used as walling material it should be lightly reinforced and the outer surface composed of a skin about 2 in. thick, and the inner surface of slabs of pumice, cork, or precast plaster.

Reinforced Concrete Panel Walls. Framed structures combining thin reinforced concrete walls are becoming more general, especially in the construction of large blocks of residential flats, etc. Under the *Code of Practice*,

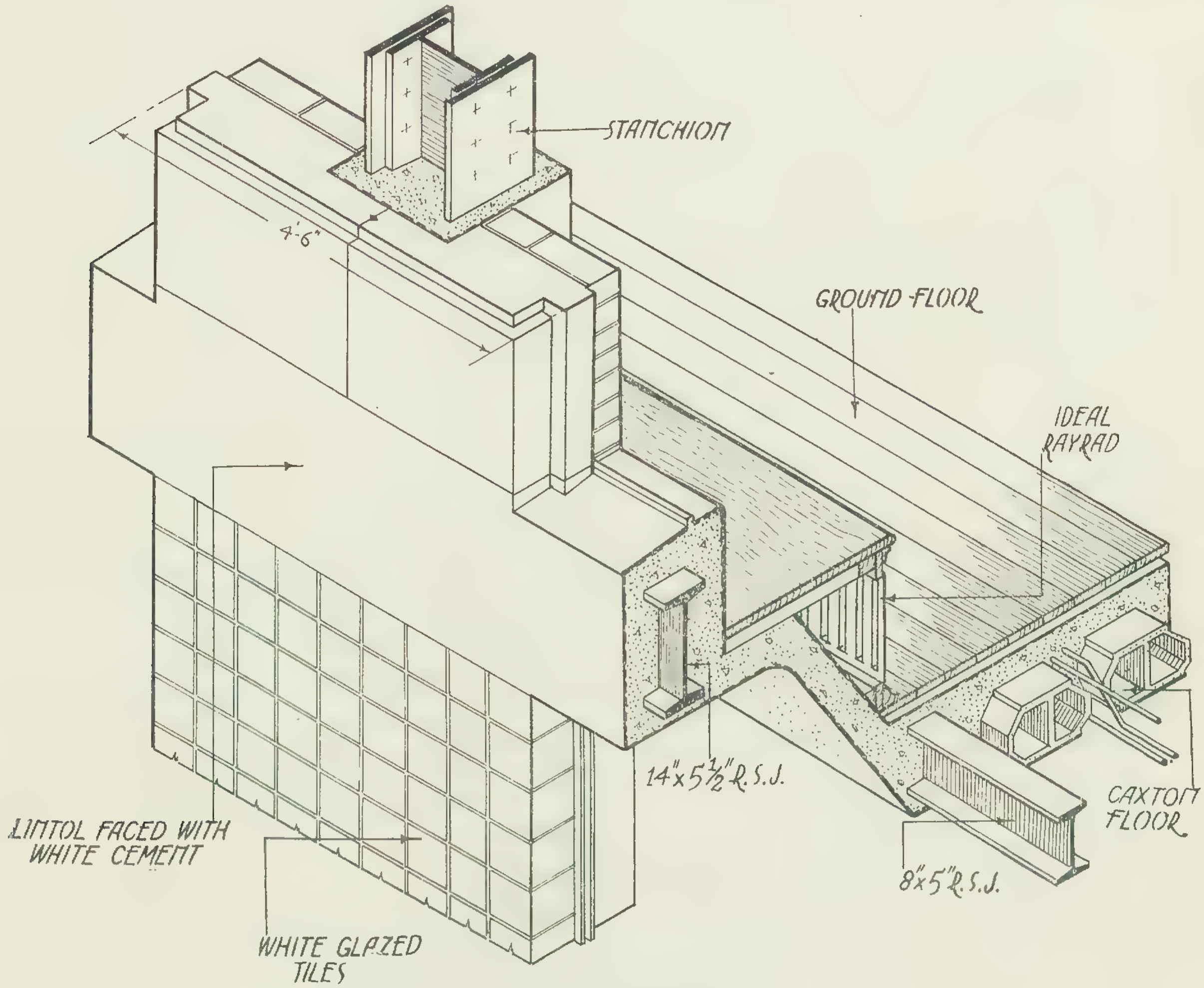

Fig. 42. Construction of External Basement Wall where Vertical Windows are Desired

Section 18, such walls "shall be of 1 : 2 : 4 (or richer mix) cement concrete properly reinforced throughout with steel. Such walls shall be at least 4 in. overall solid thickness throughout, exclusive of rendering, plaster or other decorative finish and their reinforcement shall be adequately anchored to the steel pillars and beams on all four sides." The outer surface of such walls may be rendered in cement and sand or sprayed with coloured cement, or the aggregate may be exposed. In some instances, the external surface of the concrete is covered with stone slabs or precast concrete slabs. The inside of such walls should be lined with an insulative and absorbent material, or covered with pressed fibre board sheets fastened to wood battens. The use of reinforced concrete walls has been looked upon as an expensive method of wall construction because it involves extra expense in the provision of the necessary shuttering. But concrete walls

faced with inner and outer slabs will eliminate this expense, as the slabs can be placed in position and strutted to act as the shuttering for the concrete filling as in Fig. 43.

The concrete for this method of wall construction should be of a fairly dry mix and composed of a fairly light aggregate.

External Skins. The outer slabs should be connected to the concrete filling

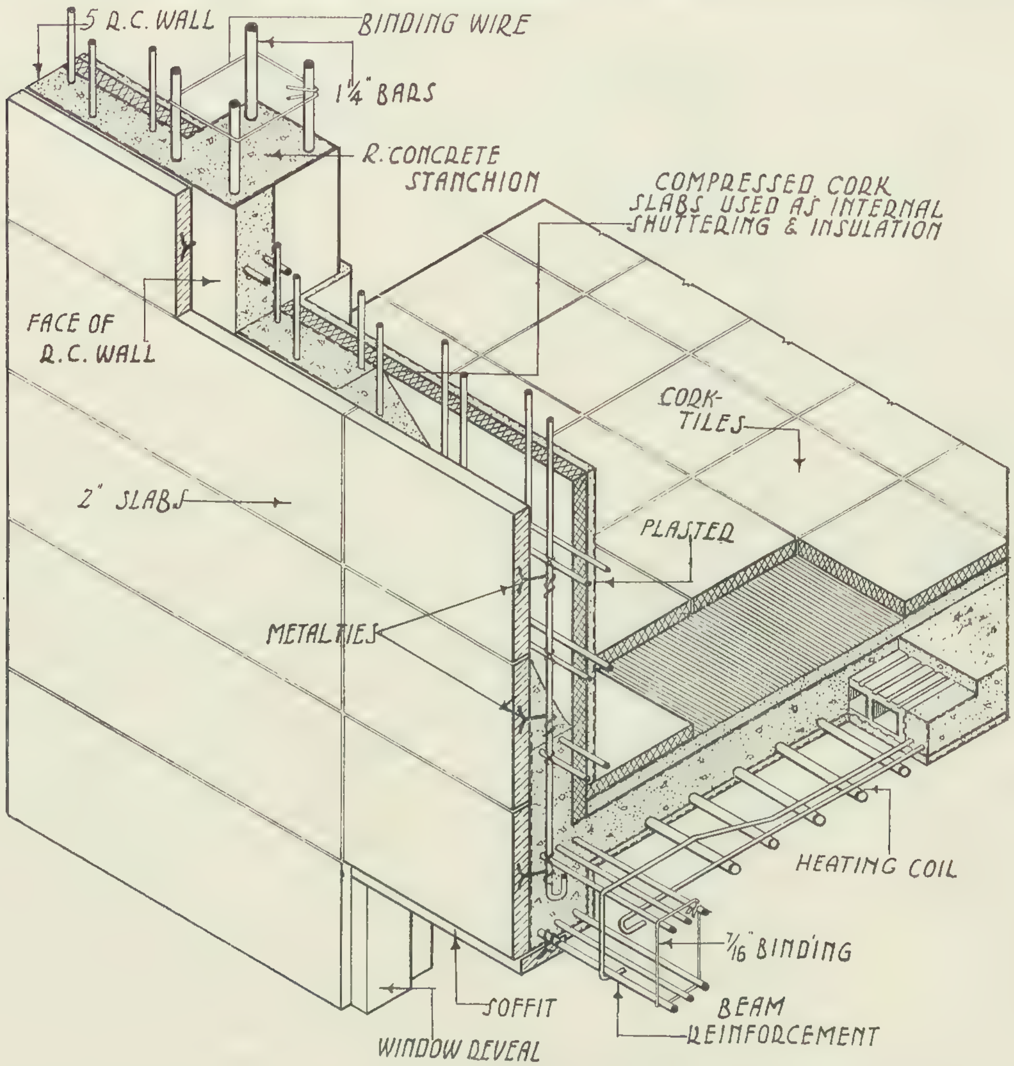

Fig. 43. Construction of Reinforced Concrete Wall Slab Faced on Both Sides

by metal ties fastened in the joints or embedded in the slabs and connected to the concrete filling, or fastened to the steel reinforcement bars, as shown in the sketch. Another method of securing the outer slabs is shown in Fig. 44. Dovetailed grooves are formed in the backs of the slabs and are filled with the concrete during the process of placing it into position. These grooves form the key and connect the slabs to the concrete without the use of metal ties.

When natural stone facings are used the expense in forming these grooves is not very great as they can be worked by machinery. When cast stone facings are used the grooves may be cast with the slabs. Terracotta facings may also be used as a veneer by omitting the back portion of the blocks and leaving projecting tongues to be concreted in the mass of the wall as shown in Fig. 45. This

sketch illustrates the construction of a concrete core wall at the junction with an upper hollow block floor.

Internal Skins. Various materials may be used in the manufacture of the inner slabs. They should, however, be absorbent and act automatically as an inner shuttering.

Precast plaster slabs are shown in the sketch (Fig. 45). These slabs are very

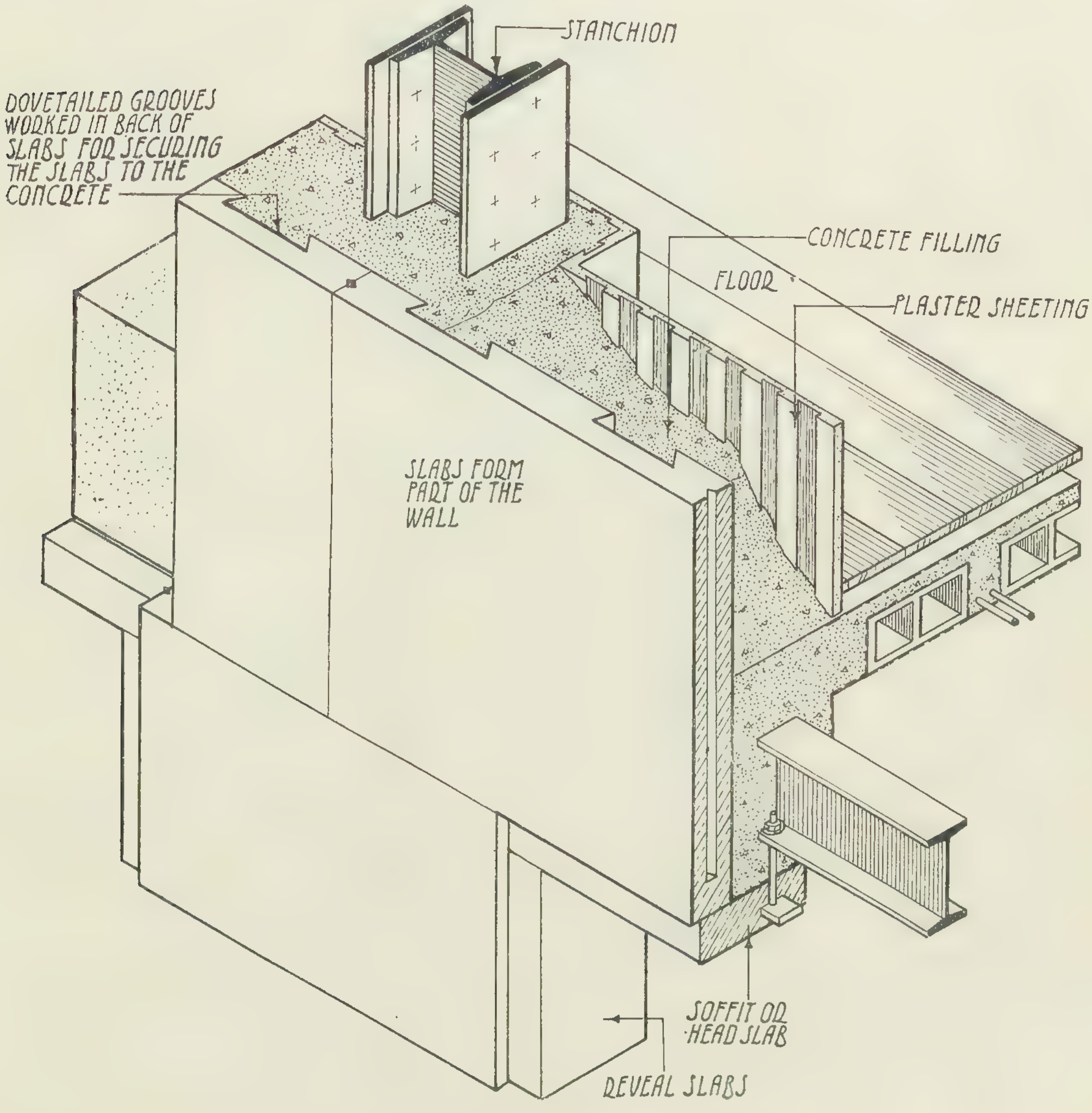

FIG. 44. METHOD OF SECURING FACING SLABS

suitable for this method of wall construction as they may be cast to sizes which suit the required dimensions of the internal piers. This means a great saving in labour in forming shuttering around the piers.

The slabs are cast with a layer of scrim in the centre of their thickness and the dovetailed grooves are formed about 4 in. apart to act as a key to secure the slabs to the concrete infilling. The outer surface of the plaster slab is usually scored or roughened so as to form a key for the finishing coat of plaster.

Pumice slabs also may be used for an inner skin. They are absorbent and the surfaces are rough and do not require any special keying arrangement.

Cork slabs too are very suitable, and because of their roughened surfaces may be used in a manner similar to pumice slabs.

Panel Walls. The changing methods of wall construction have been assisted by the provisions of the *Code of Practice for the Use of Structural Steel and Other Materials in Buildings*, 1932. In the districts where these provisions have

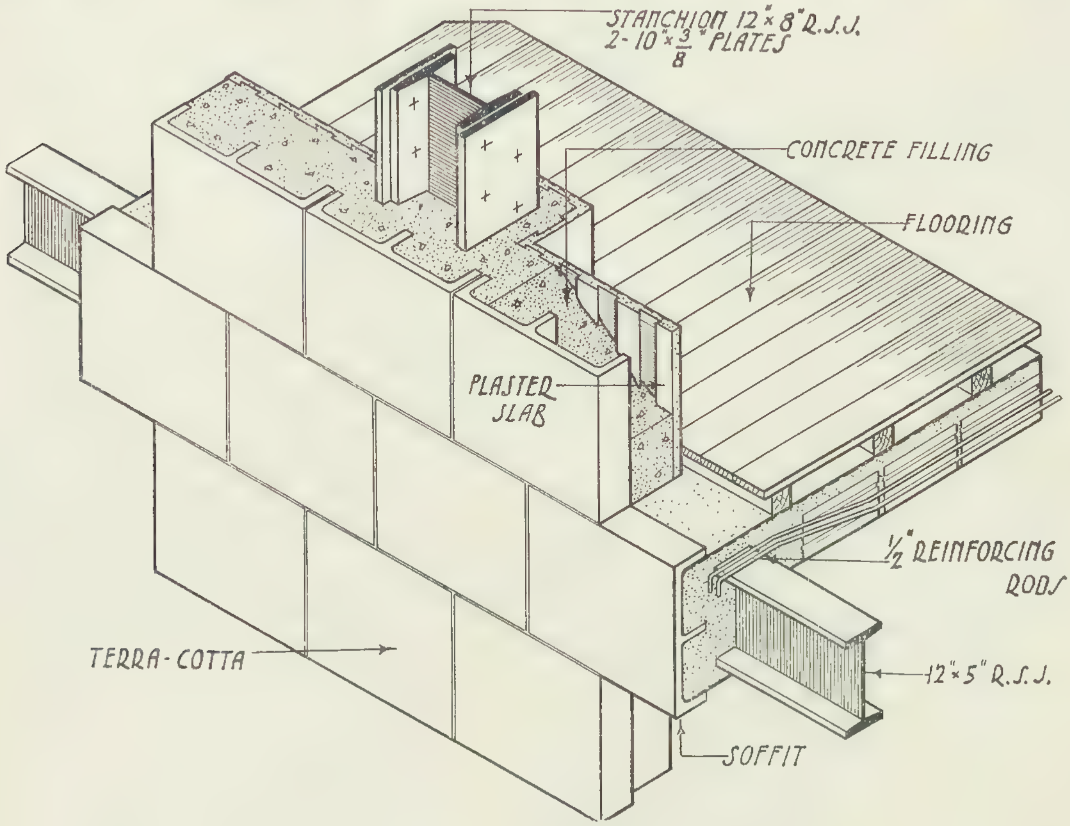

Fig. 45. Concrete Wall Faced with Terracotta

been adopted, walls are becoming lighter and more in keeping with modern requirements.

Walls which form the clothing of the framework are termed *panel walls* because they are connected to and fill the spaces between the vertical and horizontal framing members.

Under the provisions of the *Code of Practice*, panel walls may be constructed with either masonry, brickwork, hollow blocks, concrete, or a combination thereof, or any other material which provides an adequate grade of fire-resistance, strength, and durability, and built so as to be properly secured to the framework of the structure.

Faced Panel Walls. The *Code of Practice*, Section 19, states—

"Panel walls constructed of brick or concrete with a facing of terracotta, faience or stone, or of hollow blocks with a facing of bricks, terracotta, faience or stone shall be at least 13 in. overall thickness throughout, exclusive of rendering, plaster, or other decorative finish. Where the clear span between steel supports (either horizontally or vertically, according to which is the lesser) of

such walls exceeds 16 ft., the thickness thereof shall throughout be increased by at least 2 in. for each 3 ft., or fraction thereof such excess span. The brick or stone facing shall in all cases be either bonded or otherwise adequately secured to the backing."

Hollow Block Backing. It will be noticed that under the foregoing provision brick- and stone-faced walls may be backed up with hollow blocks, which is certainly a step towards lighter wall construction. Manufacturers have come

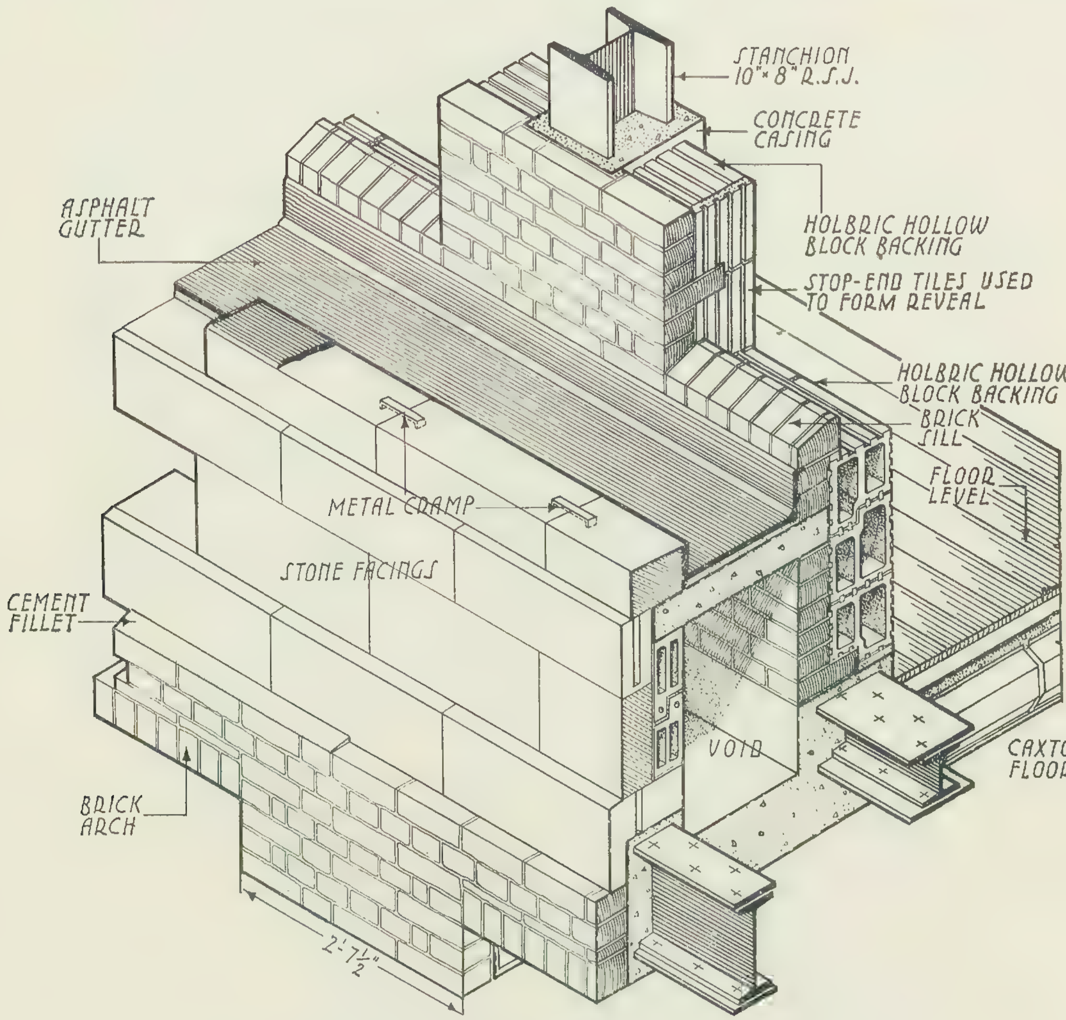

FIG. 46. BRICK-FACED WALL BACKED WITH HOLLOW BLOCKS
Showing setback in elevation.

forward to meet these new requirements and have placed on the market materials suitably formed to provide for the bonding of the facing material if desired. Fig. 39 shows an external wall built with hollow blocks and faced with stone slabs, whilst Fig. 46 illustrates the construction of a brick-faced wall having a backing of hollow blocks. The sketch also shows the construction of this type of wall at a portion of an elevation where a set-back is required. Another sketch showing hollow block backing is given in Fig. 47.

It will be noticed that the blocks, besides interlocking with each other, bond with the facing materials. This method of construction ensures a wall of light

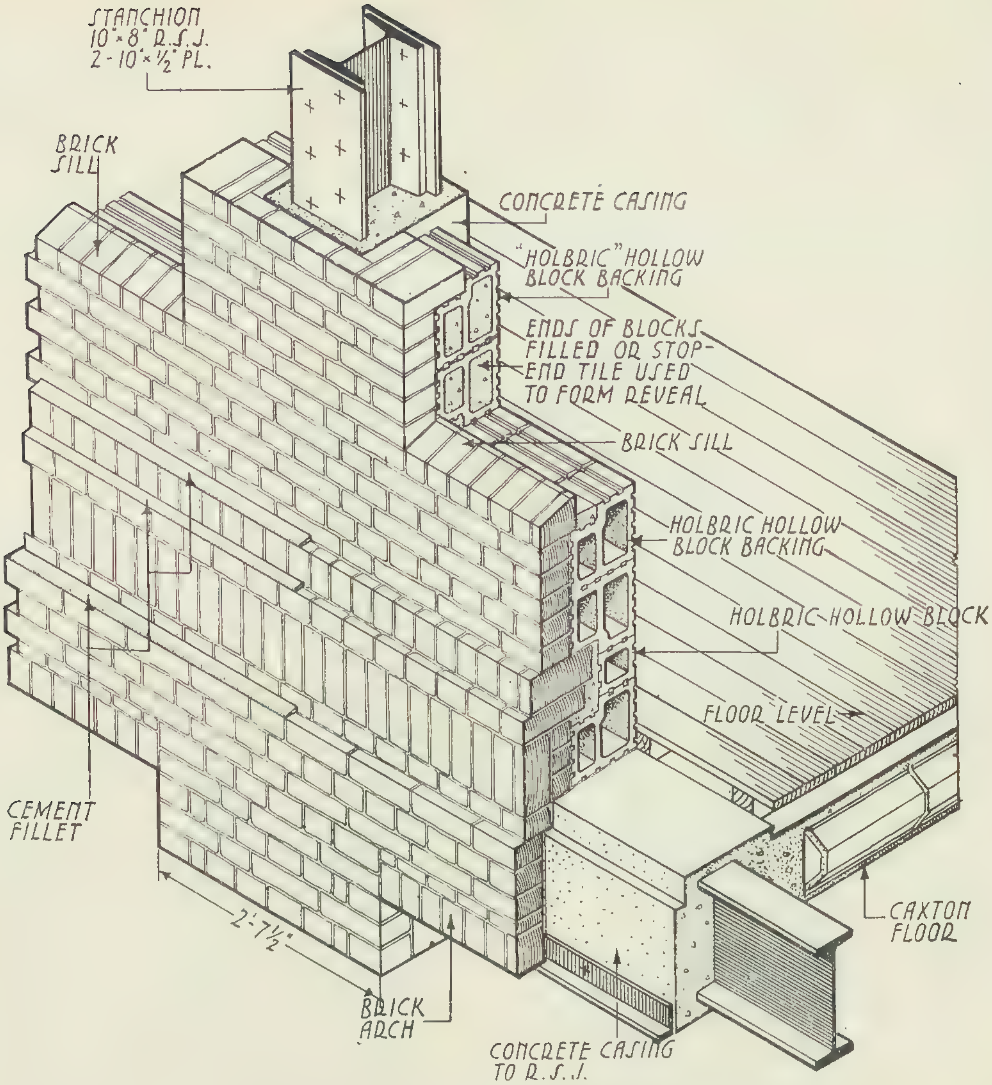

Fig. 47. Brick-faced Wall Backed with Hollow Blocks
Showing construction at floor level.

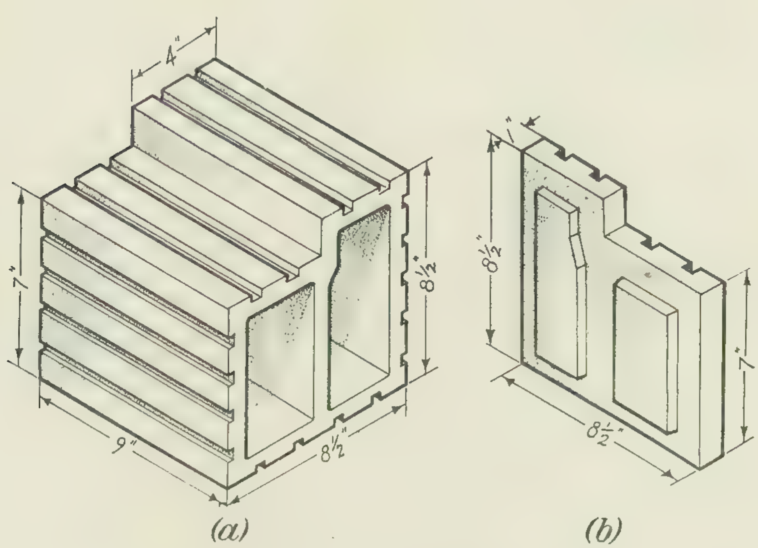

Fig. 48. Details of Hollow Blocks
(a) Detail of block. (b) Detail of end piece.

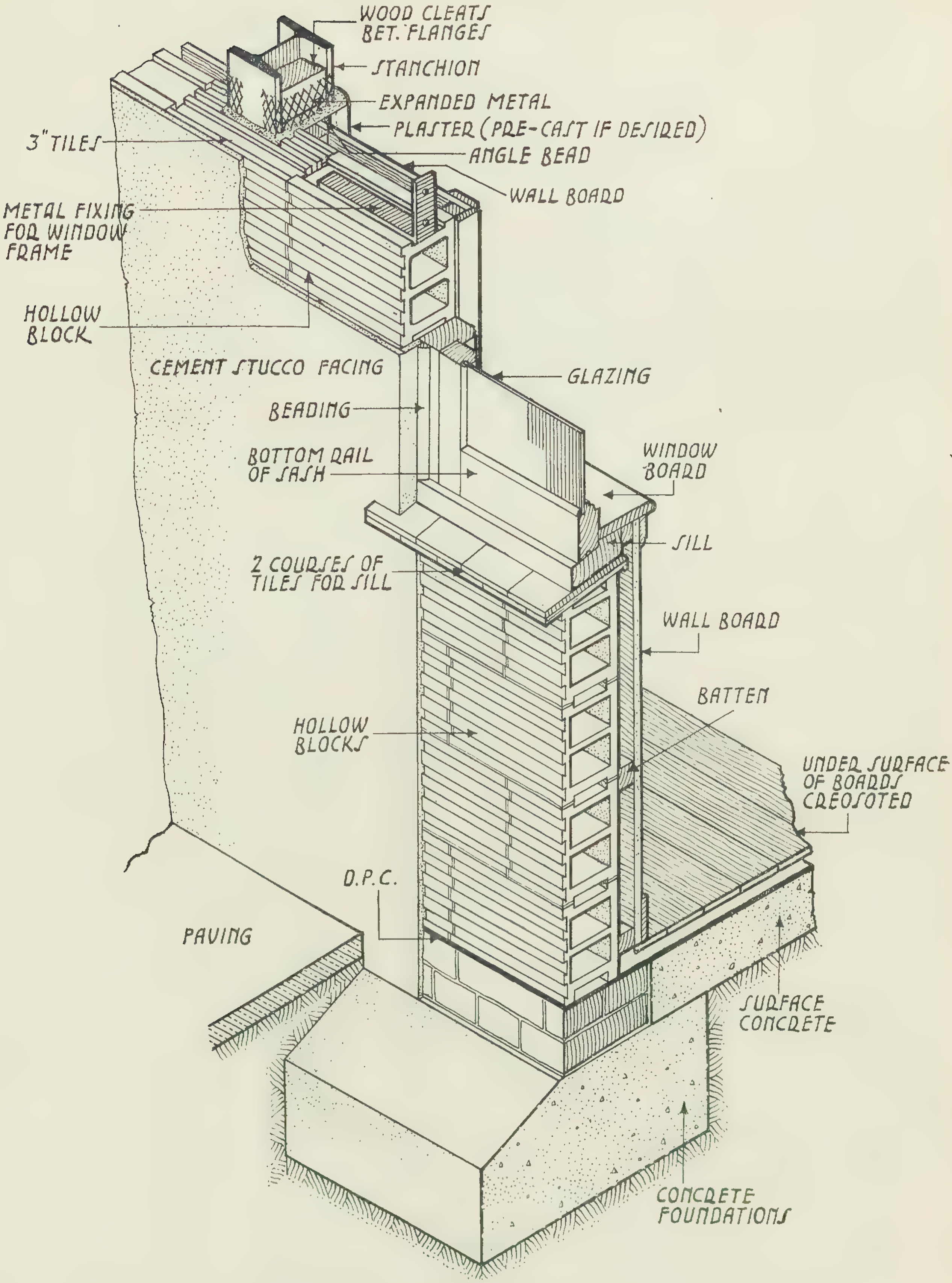

Fig. 49. Construction at Base of External Wall Built with Hollow Blocks

weight, whilst the voids in the blocks will assist in improving the insulative quality of the wall.

Details of the special blocks are given in Figs. 48 (*a*) and 48 (*b*).

Hollow Block Walls. The use of hollow blocks for the construction of walls in light frame construction has not been much developed. This is rather surprising, as this light walling material is very suitable for certain types of walls,

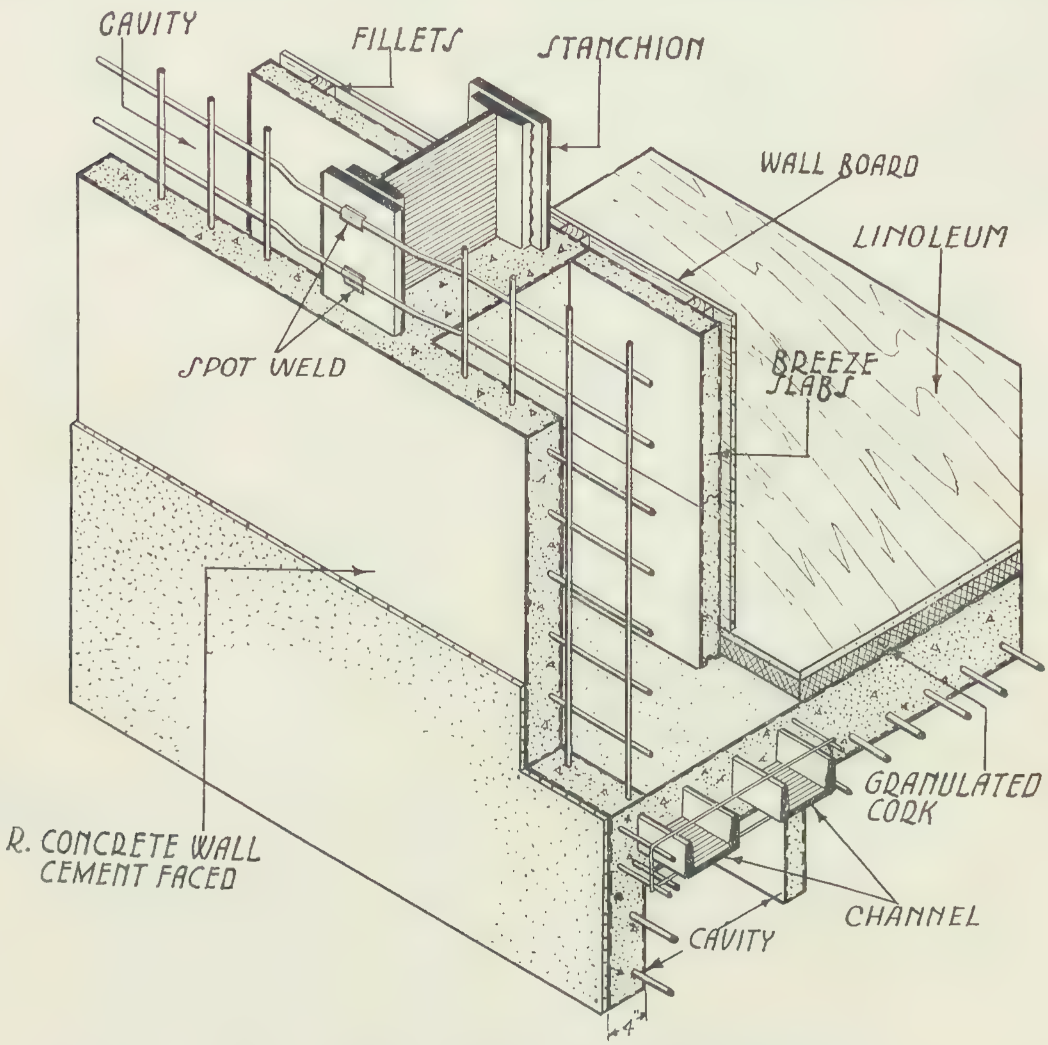

Fig. 50. Cavity Wall Built in Reinforced Concrete

and especially for buildings of a semi-permanent character. Such blocks are preferable to many precast slabs which are often used for this purpose.

The blocks are light and easy to place in position. Provided that the blocks are externally rendered with cement stucco or covered with some other waterproofing material, there appears to be no reason why they should not give excellent results.

Fig. 49 shows the construction at the base of a hollow block external wall built in combination with a light steel frame. The sketch includes the finishings at the sill and jamb of a window opening and illustrates how the blocks may be placed to provide good construction. The interior wall surface is formed by fixing wood battens to the surface of the blocks after which the battens

are covered with pressed fibre wall-boarding, which is secured to the wood battens.

If desired, the inner wall surface can be formed with plaster placed direct to the surface of the blocks.

Reinforced Concrete Cavity Walls. One of the latest methods of wall construction is shown in Fig. 50.

The wall construction consists of a 4 in. reinforced concrete outer wall, and a 2 in. breeze or pumice slab inner wall with a wide cavity between the two wall skins. These walls fill the space between the steel stanchions which, in this example, are part of a welded steel frame structure and the wall reinforcing bars are spot-welded to the structural framework.

Welded steelwork appears to be coming into prominence for structural work. It has many advantages over riveted steelwork in that lighter sections may be used, and for the purpose of calculating their sizes the beams may be regarded as having fixed ends.

In some instances ordinary steel sections are incorporated. In others "flats" are built up to form the sections. Such walls may be faced externally with a $\frac{3}{4}$ in. rendering in three coats, the first coat being a screed composed of three parts sand and one part Portland cement; the next coating being integrally waterproofed and composed of three parts sand and one part cement; and the finishing coat may contain special aggregate in the mix so as to produce any desired surface finish. The inside wall finish is obtained by fixing wood battens to the slabs and covering them with pressed fibre wall-boarding.

The inner and outer walls may be stiffened at intervals by horizontal concrete beams reinforced with steel structural members which may be welded to the steel stanchions and, as shown in the sketch, the floor slab can be supported on these beams. They are formed as part of the outer wall and act as stiffeners to the outer wall. The cavity between the walls may be ventilated and drained by the inclusion of air bricks in the outer wall and by the provision of vent holes passing through the horizontal concrete beams.

Glass Facings. When considering the choice of an external skin for facing walls, the merits of glass for this purpose must not be overlooked.

Glass is one of the hardest and most durable materials. It is relatively cheap and easy to keep clean, but it is easily broken. One of the chief problems when using glass for the external facings is to secure the sheets of glass to the wall or framework of the structure, because they will be easily broken if they are improperly attached. Owing to the difference in the coefficient of expansion between the glass and the material to which it is fixed, it is necessary to secure the sheets so that allowance is made for this variation. Also there will be certain movements in the molecules when the sheets are exposed to extreme variations in temperature due to the alternate effects of the sun's rays and driving rains.

With changes of temperature both steel and concrete expand and contract more than glass.

The difference is approximately $\frac{1}{100}$ in. in a 3 ft. sheet, between winter and summer, but this difference, although very small, is sufficient to cause the glass to crack if the sheets are held rigidly at the joints; therefore glass sheets for external facings should be fastened to the wall or structure by metal strips and embedded in mastic, and not secured to wooden plugs or grounds.

This last is an unsightly method of fixing, and there is a danger of breaking the glass.

When the sheets are fixed in a metal frame the edges of the glass sheets should be ground and rounded, thereby minimizing the danger of cracking.

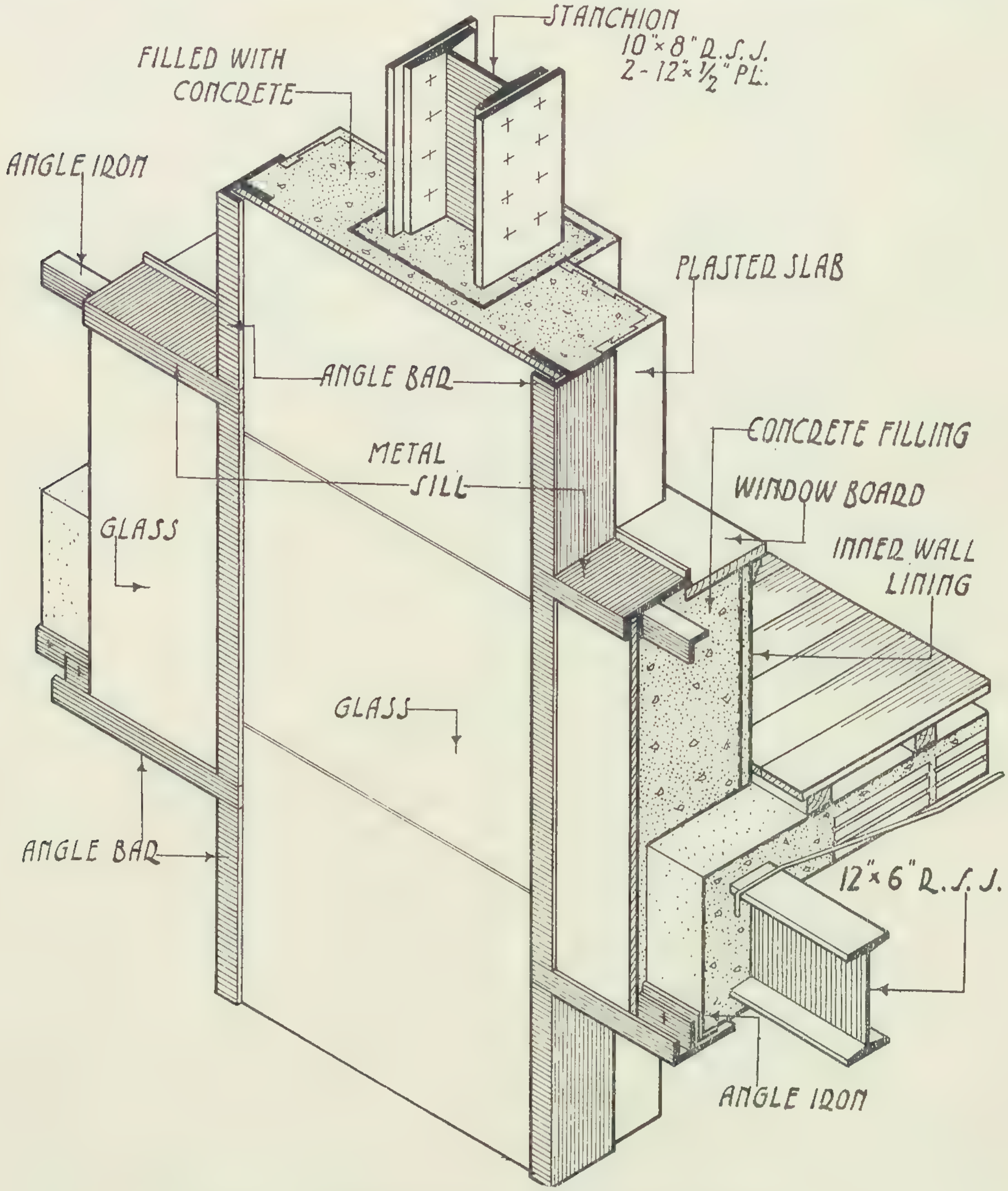

FIG. 51. CONSTRUCTION OF GLASS-FACED CONCRETE WALL

A suitable mastic for bedding the sheets is a mixture of putty, white lead and varnish, which will form an elastic cushion between the glass and the metal fixings.

Glass facings can be variously adapted to the architecture of buildings which are used at night. Bands of light, consisting of translucent glass illuminated from behind will give a very pleasing effect, and possibly in the near future may take the place of unsightly lighting devices for the purpose of advertisements which often disfigure the façades of business premises, cinemas, etc.

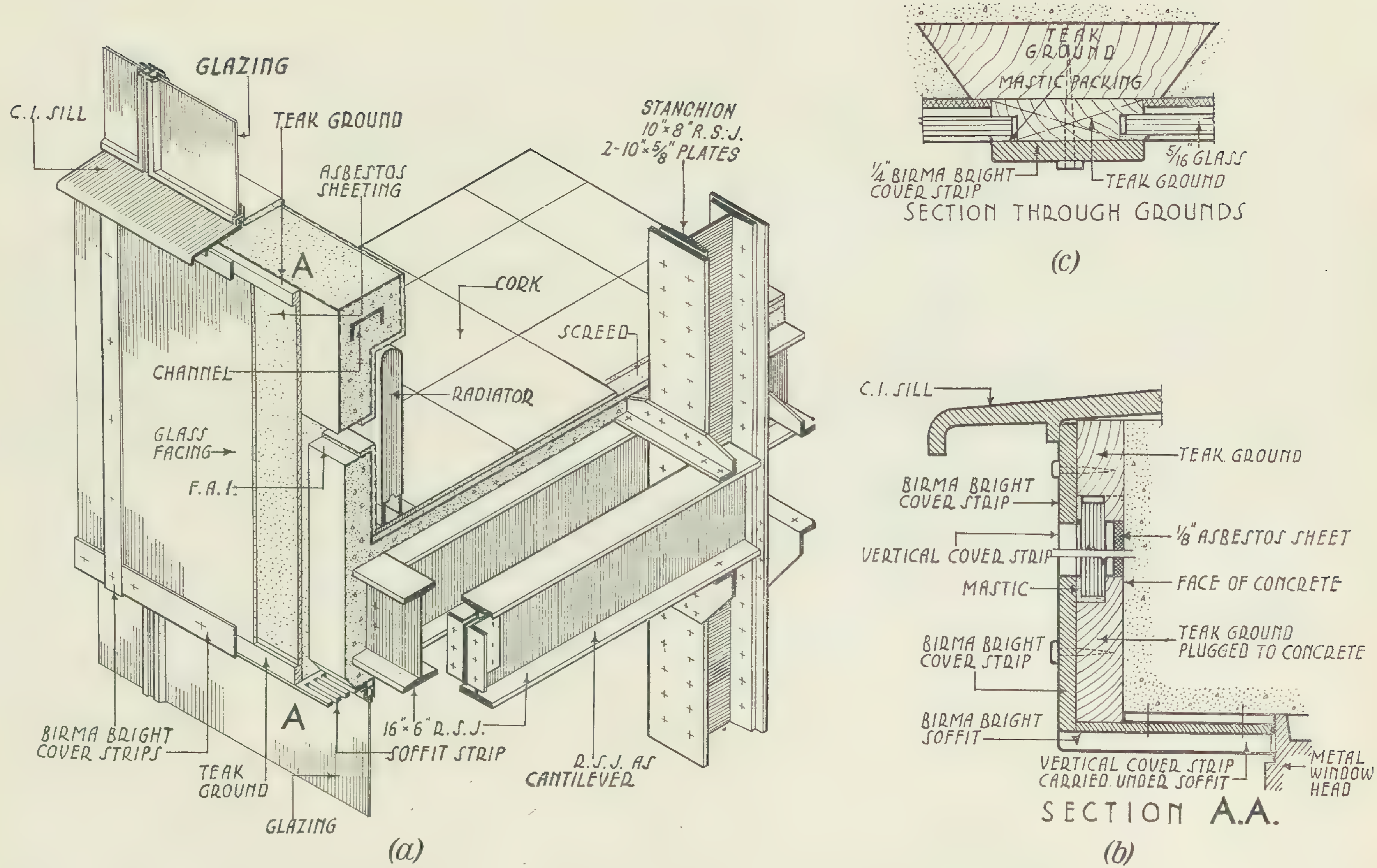

Fig. 52. Construction of Glass-faced External Wall Supported upon Cantilevers
(a) Construction of wall. (b) Section through A–A. (c) Details of fixing glass facings.

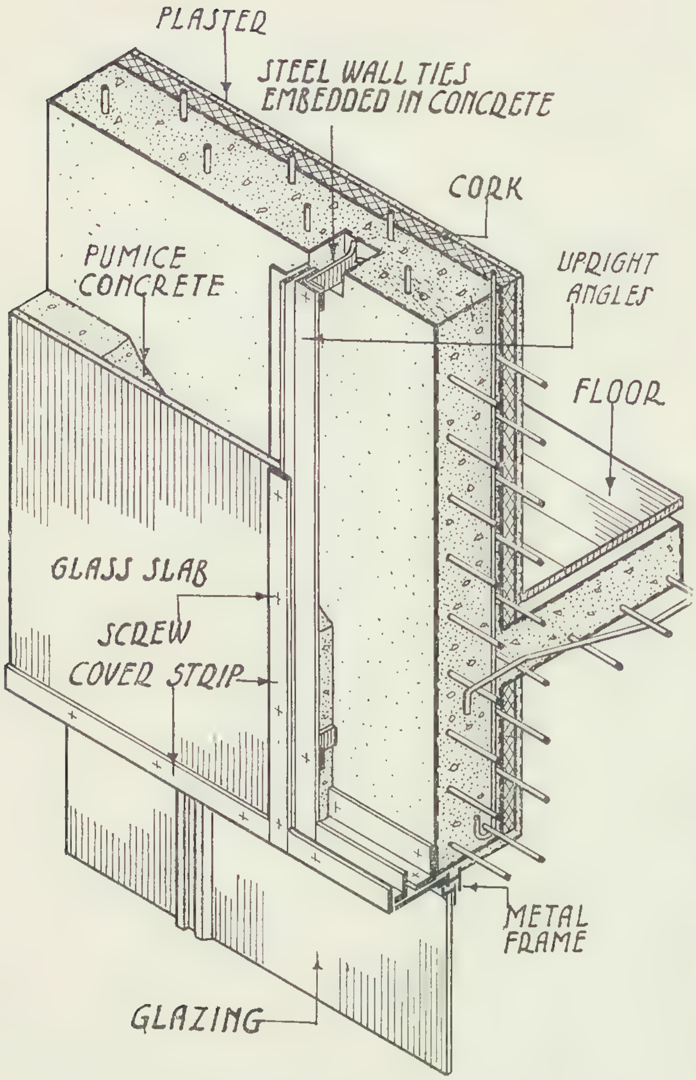

Fig. 53. Method of Connecting Glass Facing to Reinforced Concrete Wall

Figs. 51, 52 (*a*), 52 (*b*), and 52 (*c*) show various methods and details connected with the construction of glass facings. Figs. 53 and 54 are details illustrating how glass facings may be fixed to the surface of a reinforced concrete wall.

Recesses are left in the concrete walling for metal ties which are afterwards cemented into position. Then small angle sections and flats are bolted to these and form the framing for the glass sheets. The sheets are secured by covering the joints with metal cover strips which are screwed to the edge of the metal flats. The space between the concrete wall face and the back surface of the glass should be filled with light-weight aggregate or pumice concrete.

Mortarless Walls. A recent innovation in building construction is the erection of walls without using mortar for the setting of the walling materials. This method of construction may be termed *dry building*, because apart from the concrete foundations, water is not used in the construction.

Small channels and angle sections which are welded together comprise the structural framework. The external walls are constructed with steel-clad compressed fibre slabs and finished internally with pressed fibre board.

A sketch with details showing this type of wall and the construction through the sill and jamb of a window opening is given in Fig. 55.

Insulation is obtained by double glazing to the windows and by providing a fairly wide cavity in the wall area.

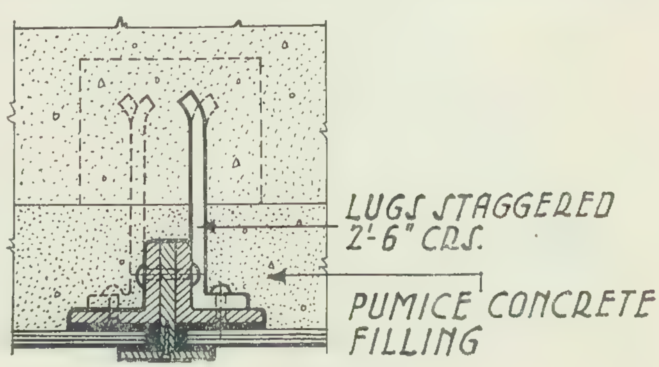

Fig. 54. Detail of Connexion to Wall

Glass Walls. The latest development of glass-faced walls is the glass wall. Glass sheets fastened in metal frames have been in use for some time, but the fixing of small squares or circular lenses into a reinforced concrete frame has been limited to such purposes as pavement lights. The modern tendency is to fix the lenses into vertical reinforced concrete frames as shown in Figs. 56 (*a*) and 56 (*b*). Construction such as that shown is very suitable in instances where a maximum of light is desired, as the entire wall panel may be a framed and glazed

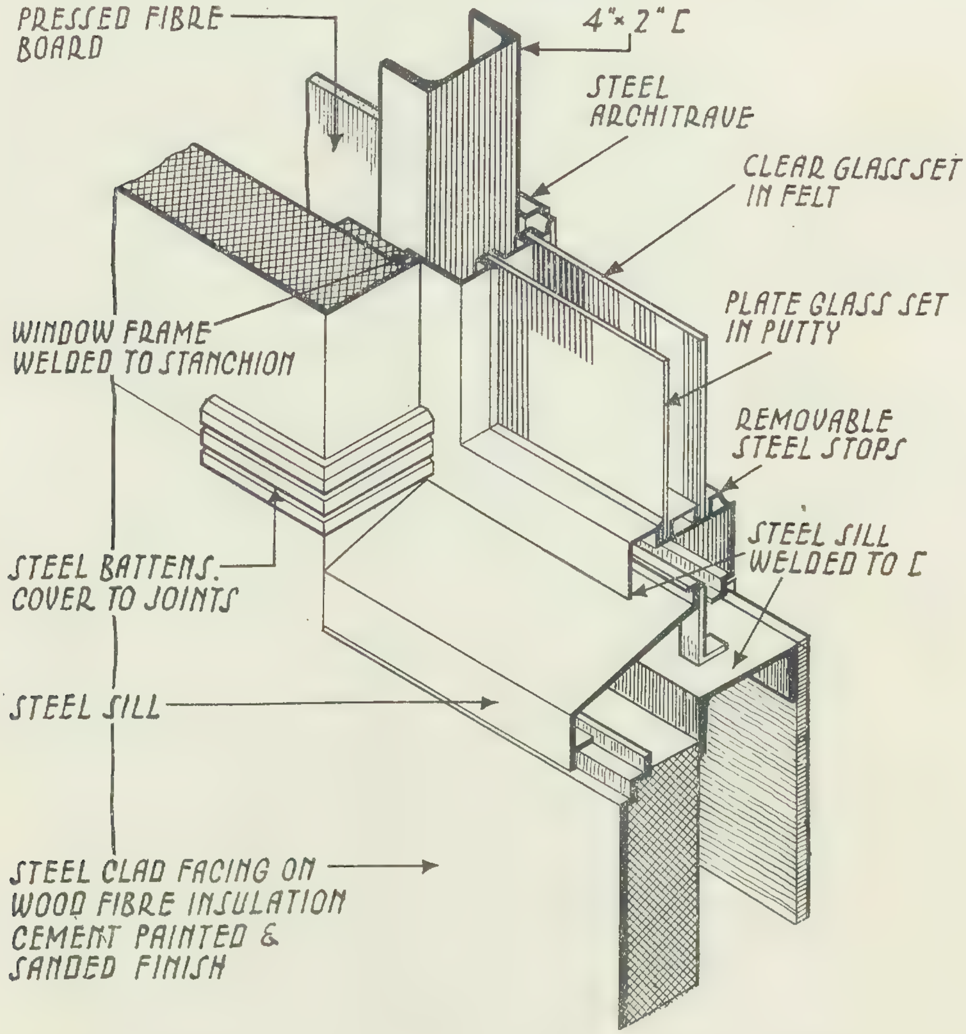

Fig. 55. Construction of Welded Steel Frame and Mortarless External Wall

area, and used in preference to timber or metal window frames. A detail of the glass unit and a portion of the reinforced concrete framing is given.

The Glass Brick. The glass brick is destined to have a very great effect on the design of buildings, because as a building material it lends itself less readily to the usual styles of architecture.

Glass bricks are very suitable as the walling material for panel walls and may be built in the same way as ordinary bricks. They have remarkable structural and insulating qualities, and extensive decorative possibilities. Fig. 57 illustrates a suggested method of construction for a panel wall of this material, built in conjunction with a reinforced concrete-framed structure. The glass wall would

be continuous throughout the length of the building, whilst the vertical structural members may be obscured by facing the concrete columns with mirrored glass as shown in the sketch. The units should be bedded with a mastic solution.

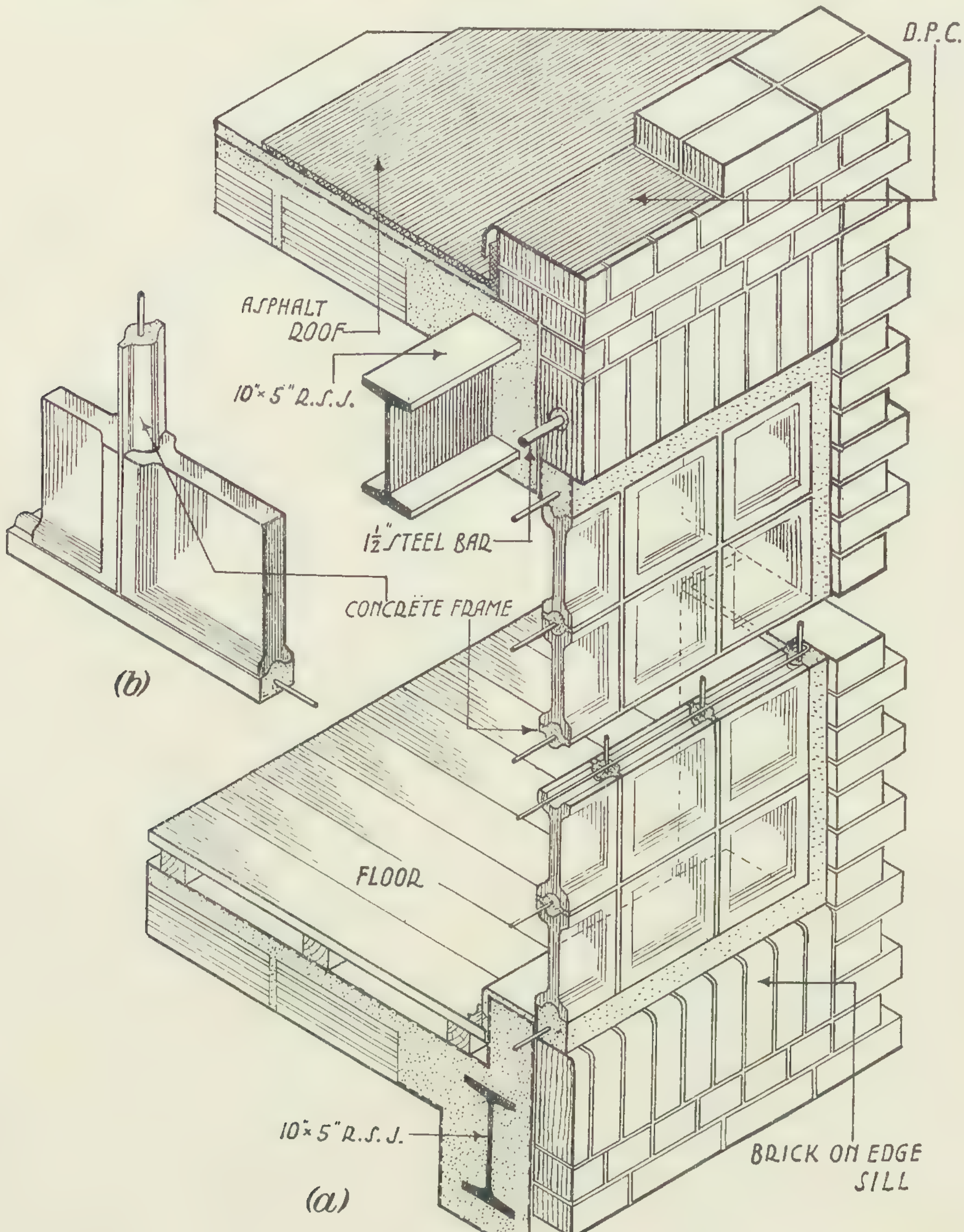

FIG. 56. CONSTRUCTION OF GLASS PANEL WALL

(*a*) Reinforced concrete frame and lenses in position.
(*b*) Detail of lenses.

WINDOW AND DOOR OPENINGS IN WALLS

Construction of Jambs. Openings in external walls require special attention in their construction. Not only should they be formed to suit the particular kind of door or window frame, but they should be built so as to prevent the transmission of moisture to the interior of the building.

Boxed-up window frames usually require the jambs at the side of the opening to be formed with a $4\frac{1}{2}$ in. rebate.

Figs. 58 (*a*) and 58 (*b*) illustrate a window jamb and show the construction

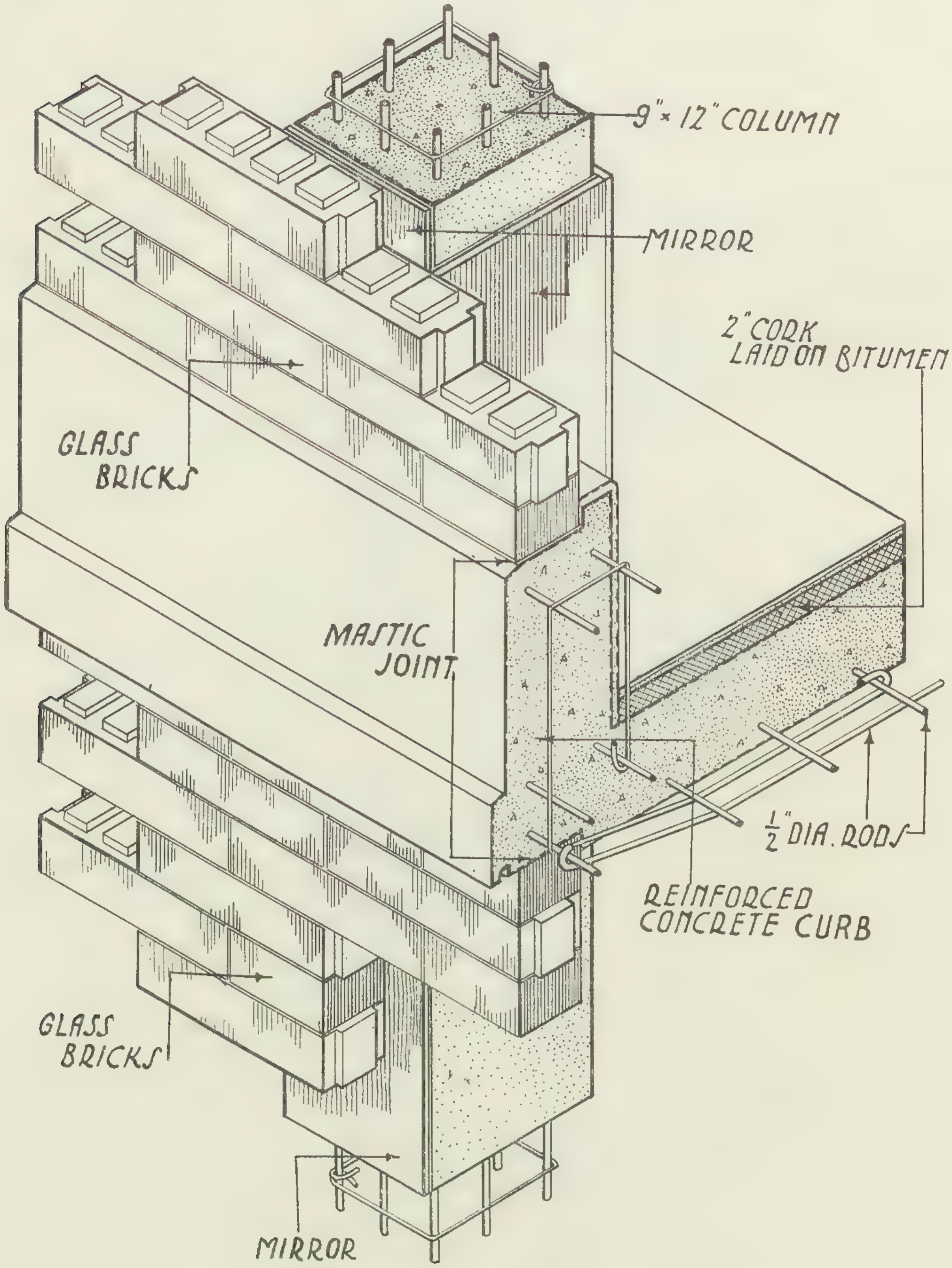

Fig. 57. External Wall Built with Glass Bricks

of a double-hung box frame with pivoted sashes. This type of sash gives easy access to the external glazing surface for cleaning purposes.

The stiles of the sashes are formed in two parts, each part having a rebated dovetailed joint along the length of the stile. The inner portion of the stile is pivoted on to the outer portion by means of the metal fittings as in Fig. 58 (*c*).

A sketch showing the construction of the complete window frame including the surrounding finishings is given in Fig. 59. Several methods have been devised for the purpose of enabling the external surfaces of the glazing to be cleaned from the inside, but none has been widely adopted.

A solid casement frame usually requires the provision of a $2\frac{1}{4}$ in. rebate to be formed in the jamb, but occasionally door and casement window frames are fitted

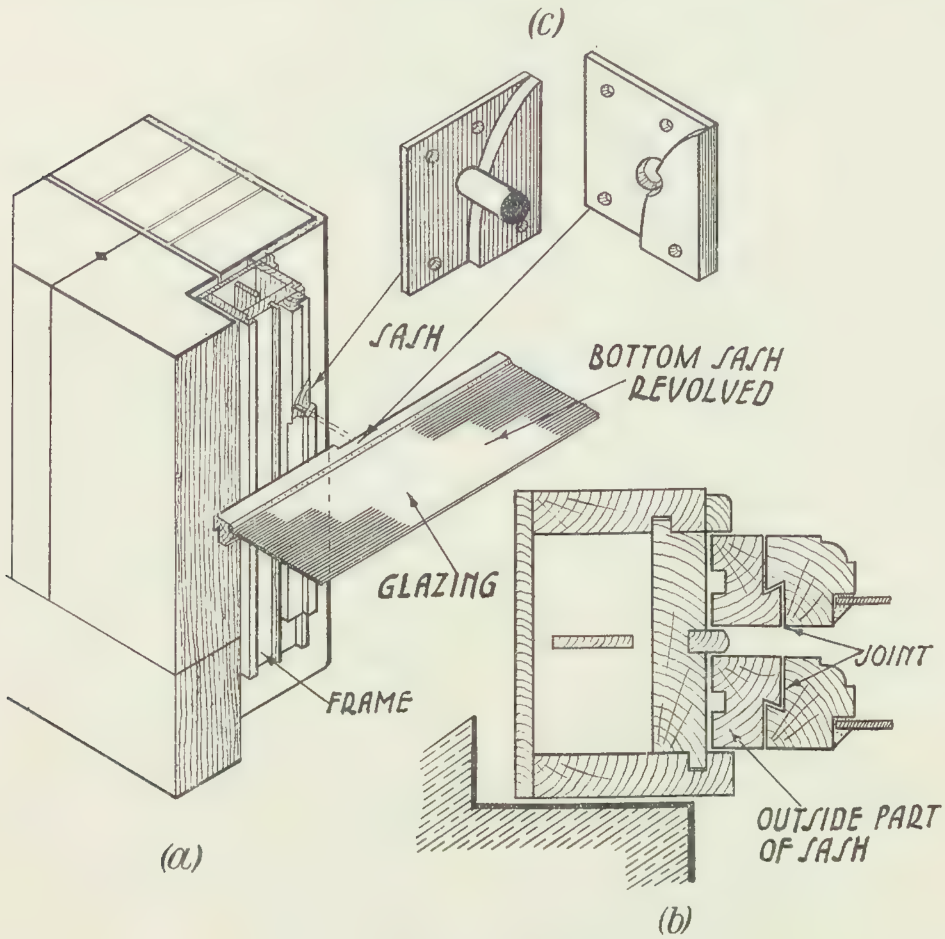

FIG. 58. DETAILS OF WINDOW FRAME WITH PIVOTED SASHES
(a) Detail of frame. (b) Detail of frame and sash. (c) Detail of metal fittings.

against straight-through jambs, in which case an angle-bead or cover-mould should be scribed to fit tightly against the walling material as shown in Fig. 60.

The sketch also illustrates the construction of the lower portion of a wood casement window frame which is designed to allow the sashes to open outwards. Another sketch of a wood casement window frame is given in Fig. 61. In this example the frame is designed for the sashes to open inwards.

Construction of Sills. Fig. 37 illustrates the construction of the jamb and sill of a window opening in a timber-framed wall. That of the jamb and sill with a solid casement frame in a window opening in a hollow block wall is given in Fig. 49.

There are many suitable methods for the construction of the bases of window openings, but it is the general practice to introduce some form of sill. The sills may be composed of stone, cast stone, brick on edge or some form of tile or metal.

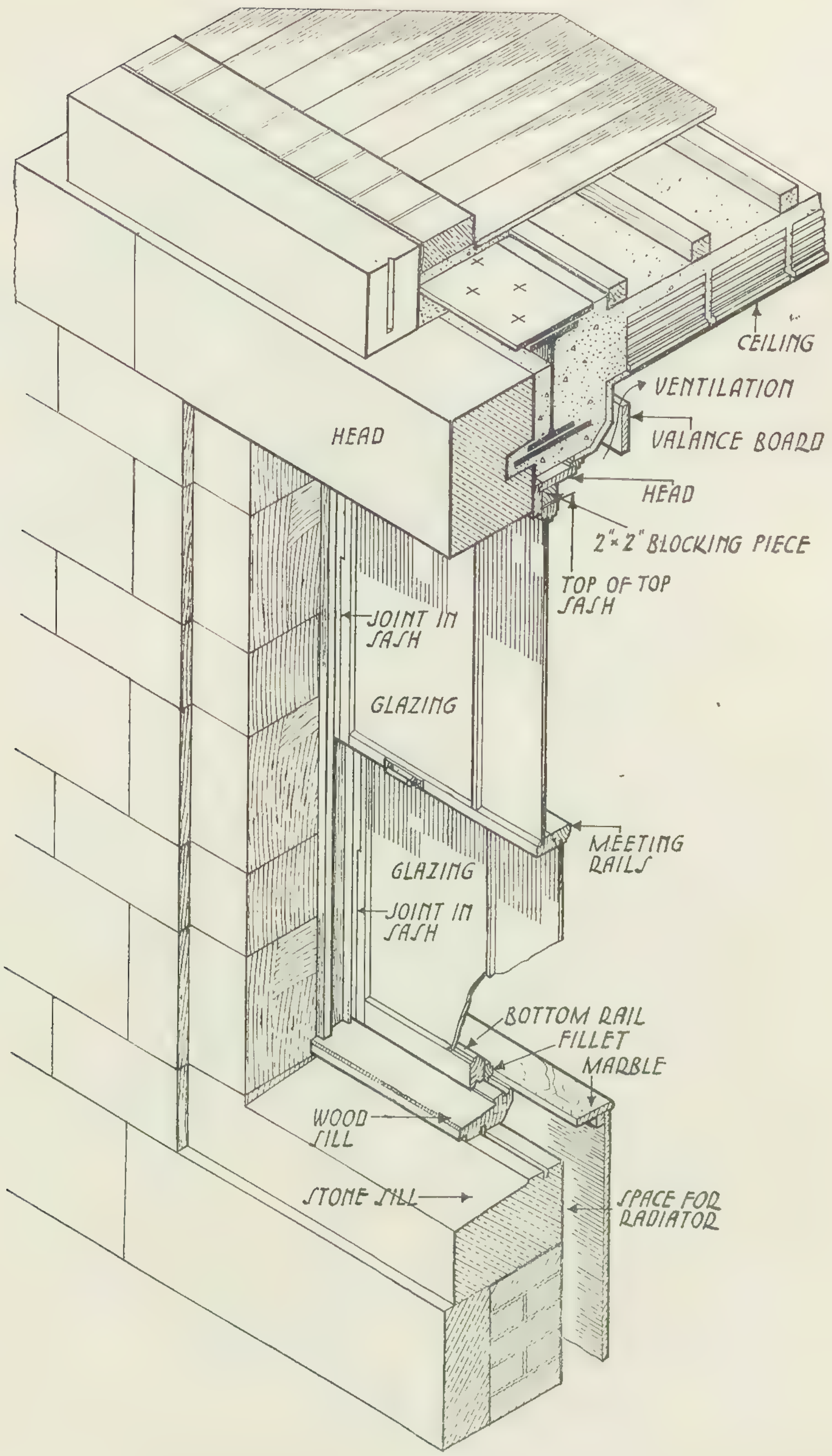

FIG. 59. DETAIL OF WINDOW OPENING COMPLETE WITH DOUBLE-HUNG WINDOW FRAME WITH PIVOTED SASHES

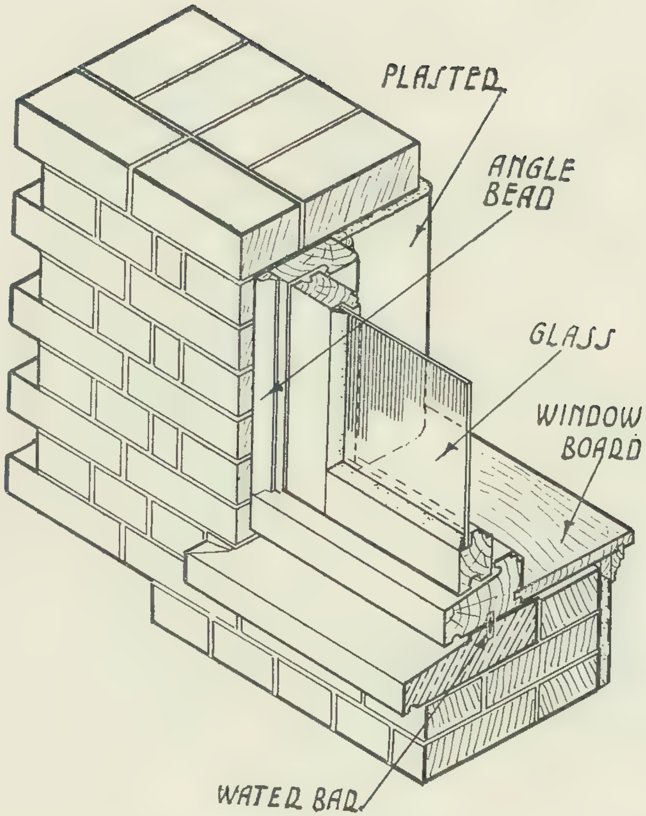

FIG. 60. WOOD CASEMENT FRAME
Sashes to open outwards.

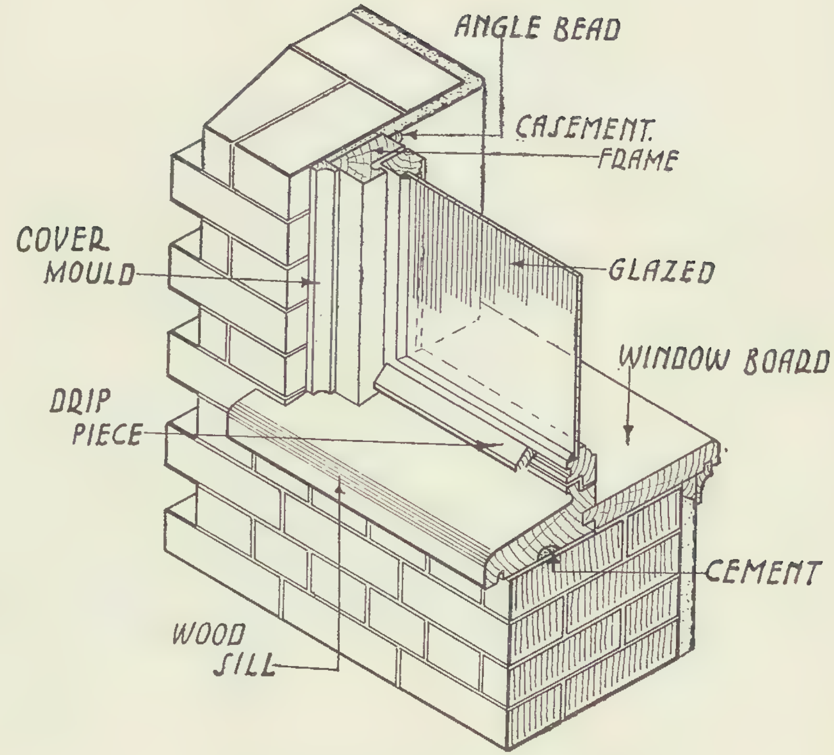

FIG. 61. WOOD CASEMENT FRAME
Sashes to open inwards.

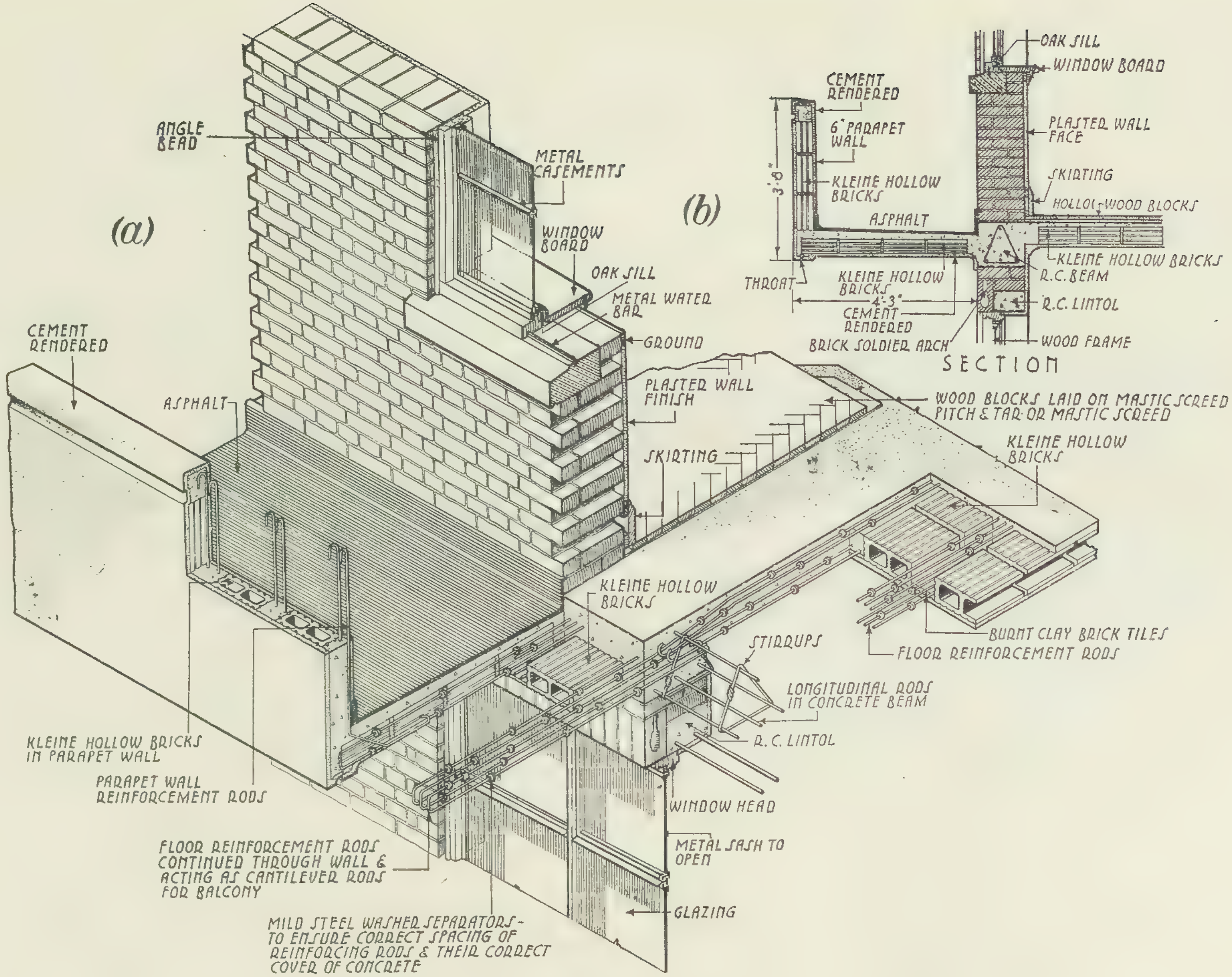

Fig. 62. Construction of Balcony Cantilevered from Floor Slab

(a) Detail of "Kleine" floor and balcony. (b) Section through balcony.

Sometimes the hard wood sill which forms the lower part of the window frame is designed to take the place of the sill proper as shown in Fig. 61.

One of the most important items to observe in the making of door and window finishings is to ensure complete insulation of the rooms from dampness and draughts. A metal water bar, embedded in red lead, should be incorporated in the construction when a hard wood sill surmounts a stone sill as shown in Fig. 60. When the hard wood sill of the frame forms the sill proper the

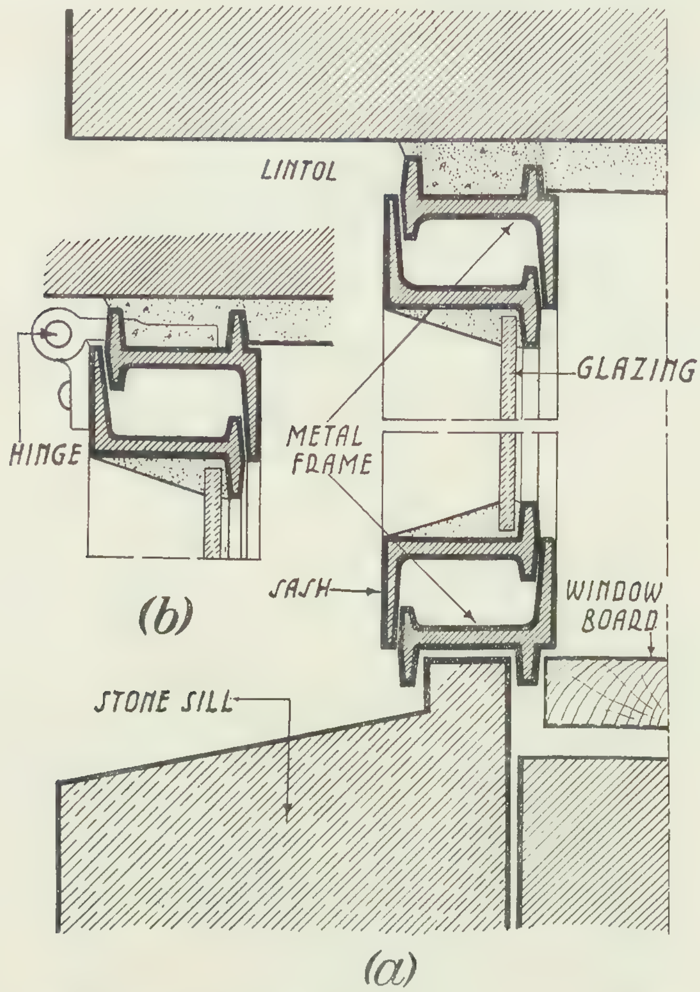

FIG. 63. DETAILS OF METAL WINDOW FRAME AND SASHES
(a) Detail of head and sill. (b) Detail of jamb.

water bar may be omitted, the wood sill being bedded upon a cement mortar joint.

The wood sill should be provided with a recess in the under surface which will become filled with mortar when the frame is placed into position as in Fig. 61.

Metal Window Frames and Trim. To make buildings resist fire as much as possible there has been a great development in the manufacture and use of metal for window frames, sashes, door frames, architraves and skirtings.

It is now common practice to use metal for these purposes irrespective of the type of building; and indeed in some modern buildings, timber has been entirely replaced by metal except for the flooring.

To meet the requirements of the design of some buildings, metal window

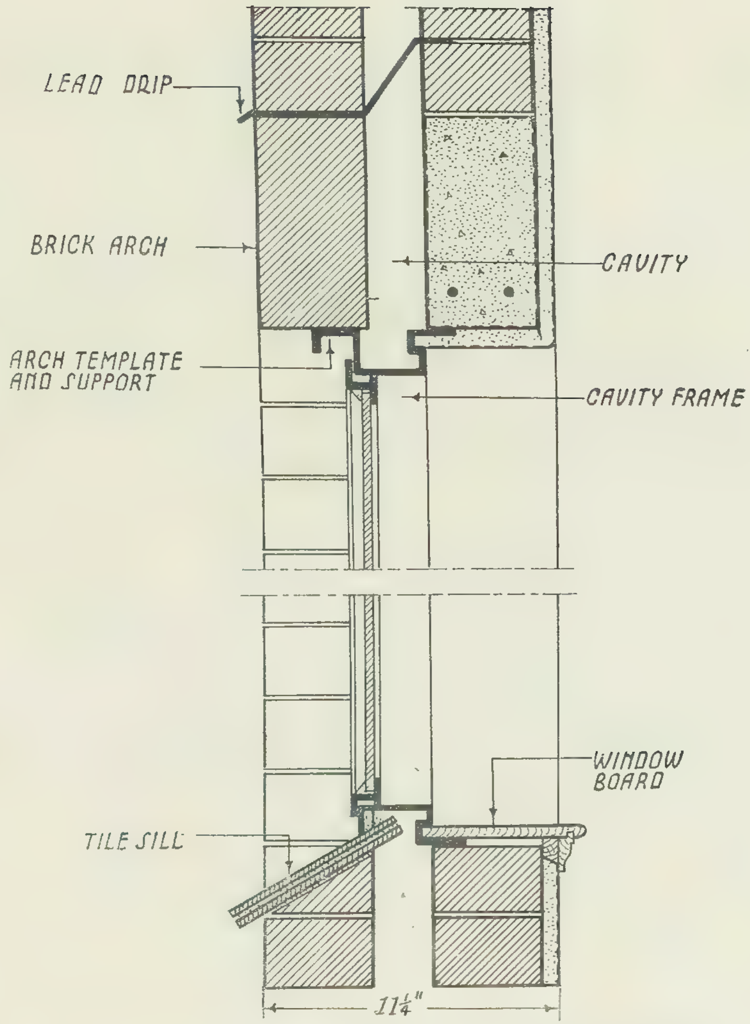

FIG. 64. SECTION THROUGH WINDOW OPENING IN A BRICK CAVITY WALL SHOWING "CAVITY" METAL WINDOW FRAME

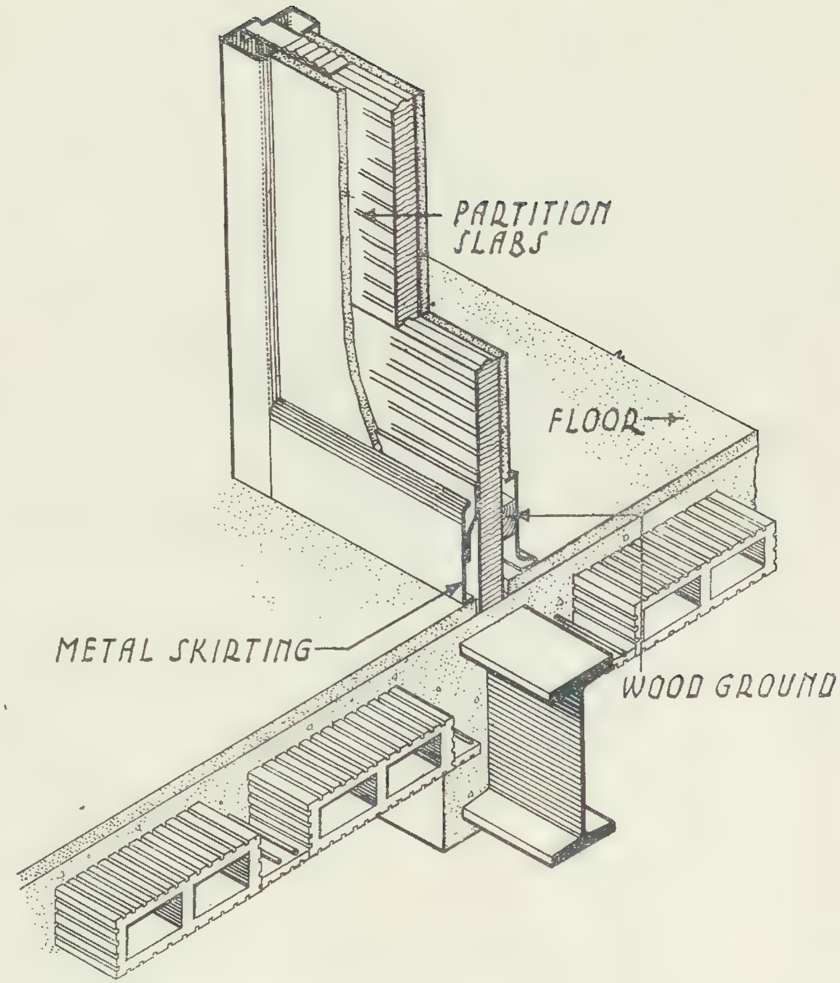

FIG. 65. "METAL TRIM" DOOR FRAME IN SLAB PARTITION WALL

sashes are fixed in solid wood frames as shown in Figs. 62 (*a*) and 62 (*b*). The metal frame is fitted in a rebate formed in the wood frame in just the same manner as when wood sashes are used.

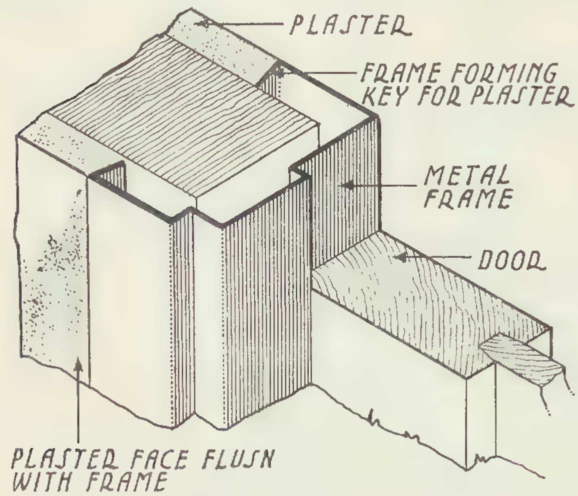

FIG. 66. "METAL TRIM" DETAIL OF FRAME

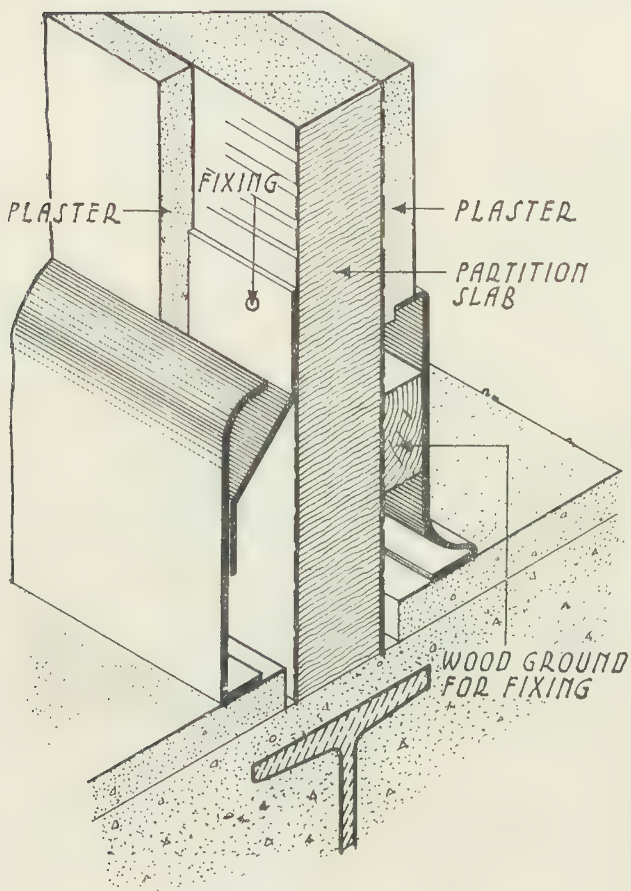

FIG. 67. "METAL TRIM" DETAIL OF SKIRTINGS

This figure also shows how a hollow block and concrete balcony may be combined or formed continuous with a floor slab. This is a very suitable method for blocks of flats, etc., where balcony accommodation is an important feature in the design.

Metal frames have many advantages over wood frames. One of the chief of these is that they allow for a larger glazing area and therefore permit the maximum amount of light to enter the room.

Metal frames should be painted frequently, especially in salt-laden atmospheres where they are more liable to be affected by corrosion.

Figs. 63 (*a*) and 63 (*b*) give the necessary details of a metal frame and sash. The sash is shown hinged to the stile of the metal frame to open outwards.

When metal frames rest upon stone sills, the sill should be formed so that the lower member of the metal frame will fit over the top portion of the stone sill as seen in the detailed sketch.

Fig. 64 is a section through a tile sill of a window opening in a cavity wall. It will be noticed that the tiles project into the space formed in the metal sill, thus preventing any moisture passing under the sill into the cavity. A recess is also formed in the metal sill to house the window board.

A metal water bar is not necessary in this type of window.

It is important that the bases of window openings should be provided with means for throwing the rain-water clear of the wall surface. To accomplish this an efficient drip should be included in the design of the sill, and the exposed

top surface of the base member should be weathered or inclined to the horizontal.

Metal Trim. With the production of fire-resisting structures, metal has been introduced into buildings in more than one form.

Steel is now used universally for the structural members. Metal window frames are being used very extensively, therefore it is only to be expected that steel would be used for the internal finishings.

It is a moot point whether this displacing of wood by metal is a step in the right direction. We have become accustomed to the use of wood for the internal

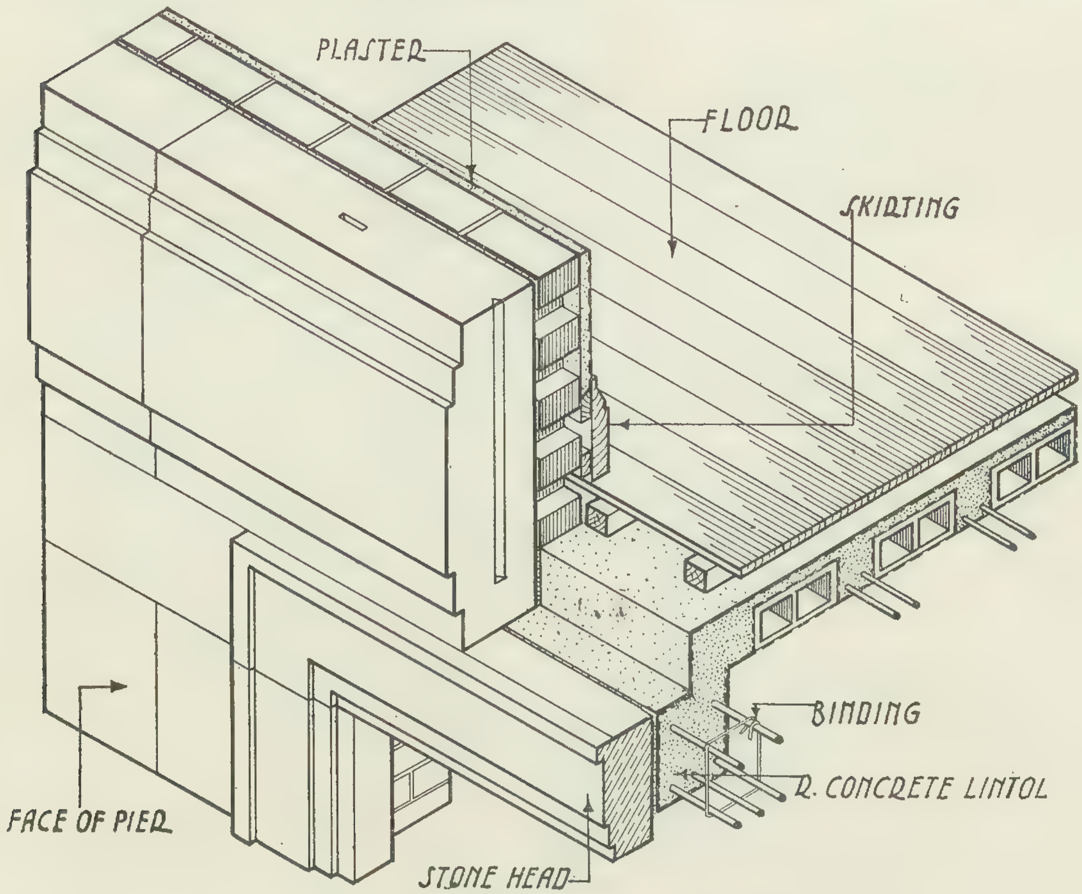

Fig. 68. Construction of Stone Head over Window Opening

finishings, and it may be said that there is no other material which surpasses it for beauty and effectiveness. The coming of new methods in the constructing of walls is largely responsible for the change from wood to metal. At least some argument from the point of view of utility can be advanced for finishings in the latter material. Metal door frames appear to be particularly suited for the construction of door openings in hollow block and slab partition walls, because they assist in stiffening the wall. The wall slabs also are easily bonded against the frames.

Metal trim may be made from sheet steel or sheet bronze and used for skirtings, architraves, jamb castings, door frames, etc.

Joints in skirtings may be finished by fixing cover pieces over the joints, and external and internal angles may be finished with special mitre pieces. The

provision of these cover or mitre pieces accelerates construction as it is not necessary to resort to accurate cutting for the various lengths.

The finished surface of steel trim is usually enamel, which is fired on or applied with a brush. Decorative effects may be produced by imitating some of the well-known hard woods.

A metal door frame in a slab partition wall is shown in Fig. 65. Enlarged

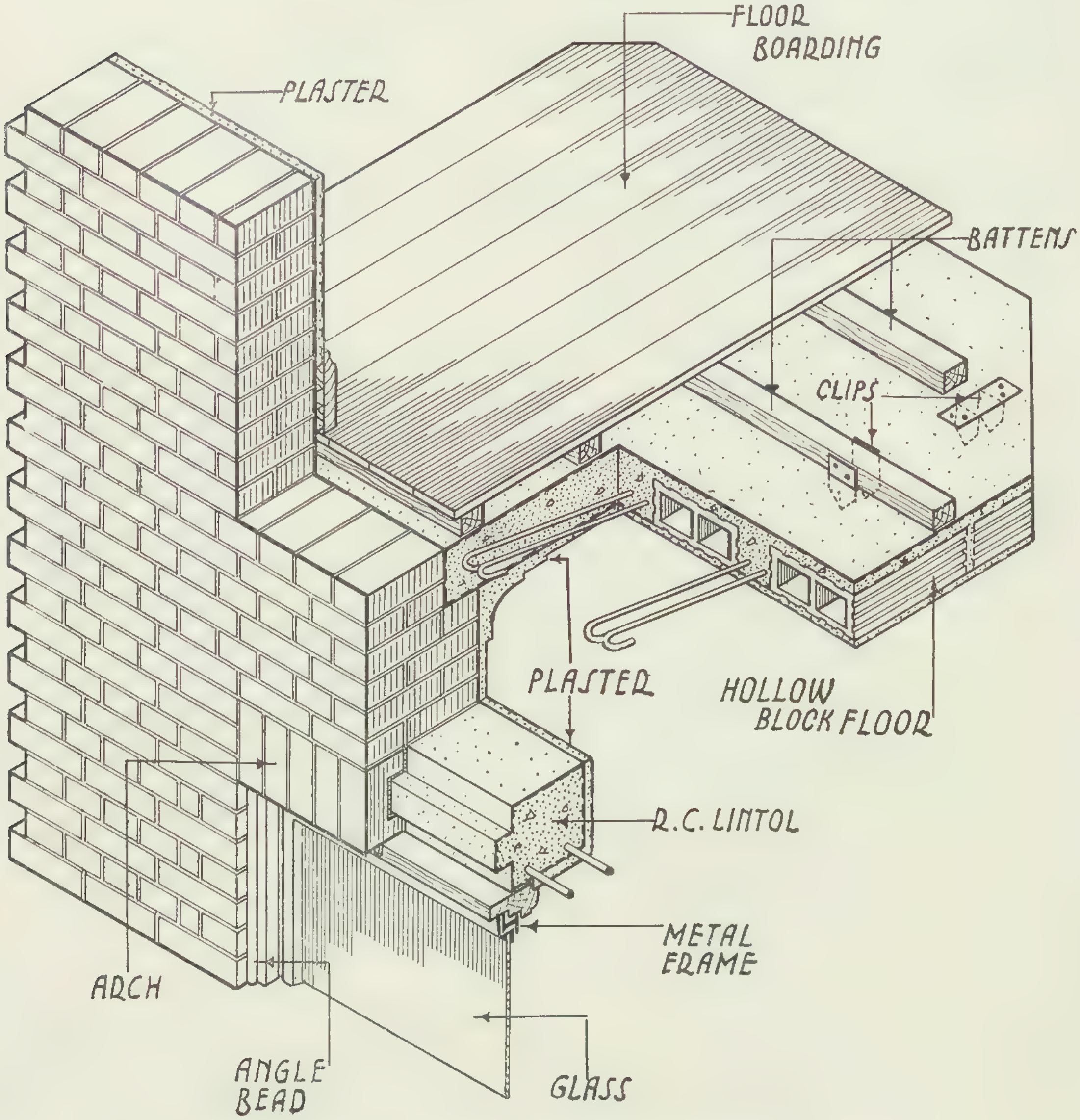

FIG. 69. BRICK SOLDIER ARCH SUPPORTED UPON REINFORCED CONCRETE LINTOL

detail sections showing the fixings for the door frame and the skirting are given in Figs. 66 and 67.

Construction at the Top of Openings. Door and window openings are bridged at the top by arches or lintols, according to the design of the building; but in modern practice lintols are used more frequently than arches.

A lintol is a horizontal member which spans an opening in a wall. A stone lintol is usually known as a *stone head*, but if the head is made up of more than one stone then the head is a *flat arch*.

Unless the individual stones are supported on steelwork, the joints between them should radiate from a common centre; thus the arch would be self-supporting.

A sketch showing a portion of a stone head over a window opening is given in Fig. 68. The sketch includes also a reinforced concrete lintol behind the stone head, which is intended to support or carry the loads transmitted from the floor.

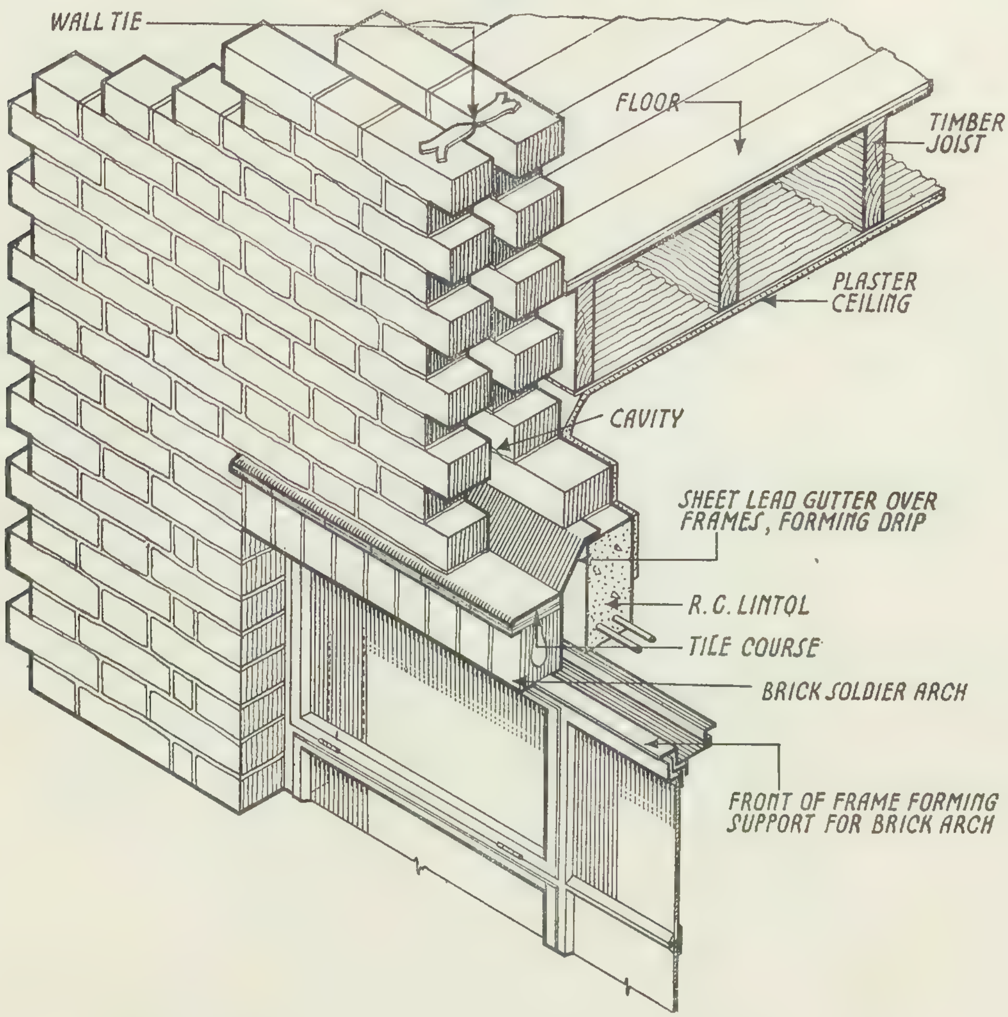

Fig. 70. Brick Soldier Arch Supported upon Metal Window Frame

A flat arch in brickwork is known as a *cambered arch* because the soffit of the arch is given a slight curve or camber. This, it is considered, prevents the appearance of sagging. A concrete lintol should be formed behind the face arch and should be of sufficient strength to support the loads which are to be transmitted from the floor and wall above the opening.

It has been the practice to construct rough brick relieving arches to carry these loads. Thus the brickwork filling or core was supported under the relieving arch on a timber beam which spanned the opening and formed the fixing for the head of the window frame. This method of construction has entirely disappeared and precast lintols made of reinforced concrete, or reinforced concrete lintols, cast *in situ*, are preferred.

Soldier Arch Construction. The modern tendency in brick arch construction is to substitute soldier arches for cambered arches. The bricks are placed side by side with their lengths vertical, so as to form a lintol over the opening, as shown in Fig. 69.

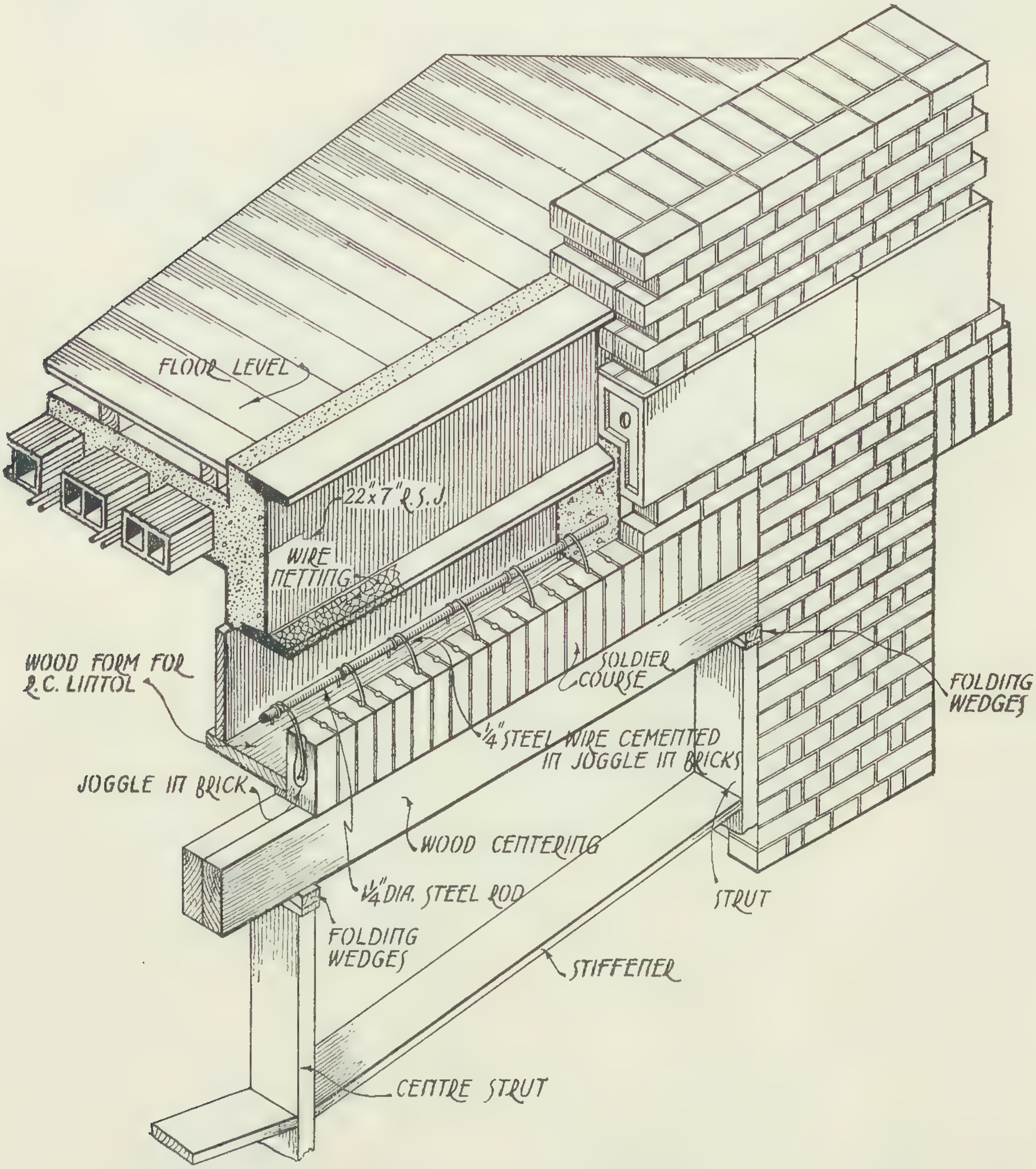

Fig. 71. Brick Soldier Arch Attached to Reinforcement of Concrete Lintol

These arches depend very largely for their stability upon the strength of the mortar between the bricks.

Therefore when brick soldier arches are built over openings of large span, the bricks should be supported upon steelwork, or upon a reinforced concrete lintol placed behind the arch. This may be done as shown in the sketch by recessing the back surface of the arch bricks and allowing the concrete of the lintol to fill the recess.

Another method is shown in Fig. 70. This sketch illustrates the construction of a soldier arch $4\frac{1}{2}$ in. on face spanning an opening in a cavity wall. In this instance the bricks are supported upon a metal projection which is part of the metal frame, whilst the inner wall is supported upon a reinforced concrete lintol. To prevent any moisture penetrating into the interior of the building by way of the cavity over the window frame, a sheet lead gutter should be formed across the base of the cavity and over the opening, as shown in the sketch.

Another method of supporting soldier arches which are intended to span large openings is illustrated in Fig. 71. In this example the bricks are shown

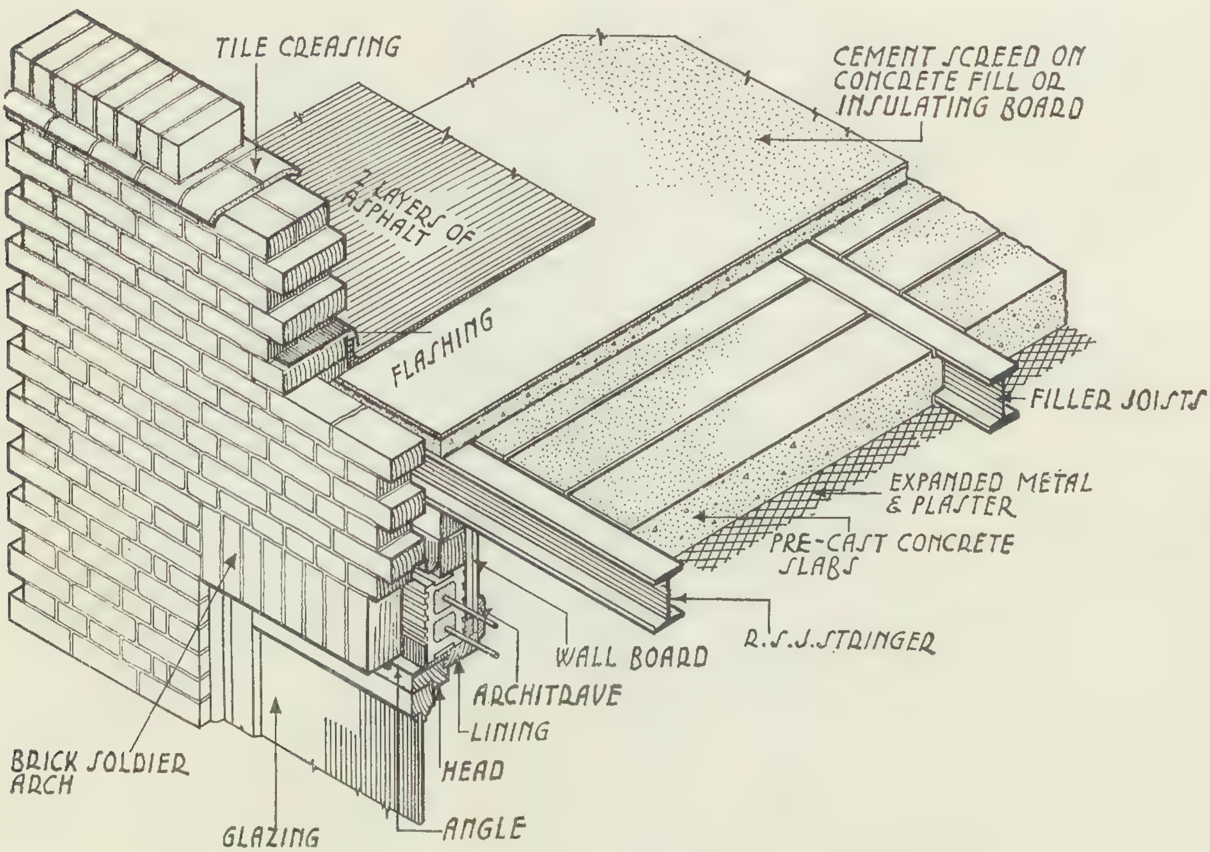

Fig. 72. Brick Soldier Arch Supported upon a Steel Angle Section

attached to a steel reinforcement bar which is embedded in the concrete lintol behind the arch. Brass wire is connected to the reinforcement and inserted in the joints between the bricks. The joints are finally filled with Portland cement grout and the concrete for the lintol placed in position after the cement grout has had time to set.

When constructing an arch such as this, care should be exercised in providing a rigid timber centre for the support of the arch, and the wall above should be constructed so that its weight is kept clear of the arch. Another method often adopted is to reinforce the bricks by cutting a hole through the centre of each brick and inserting a steel rod, or in other words the bricks are threaded on a steel rod, and the ends of the rod are built into the brickwork on either side of the arch, as illustrated in Fig. 56 (*a*). By this method of reinforcement the arch may be formed, or put together, before being placed in position over the opening.

Fig. 72 shows the construction at the head of a window opening in a brick cavity wall. A soldier arch is shown spanning the opening and supported upon a steel angle section. Here the lintol at the back of the arch is formed by filling the voids in the hollow blocks with fine Portland cement concrete, and at the same time inserting one or more reinforcing bars.

In this example the cavity wall is formed by building a 4½ in. outer wall in brickwork and a 3 in. breeze slab inner wall, the loads being carried by the steel frame. An alternative method of forming the lead gutter across the cavity over the window opening is also shown in the sketch. The bottom surface of the gutter

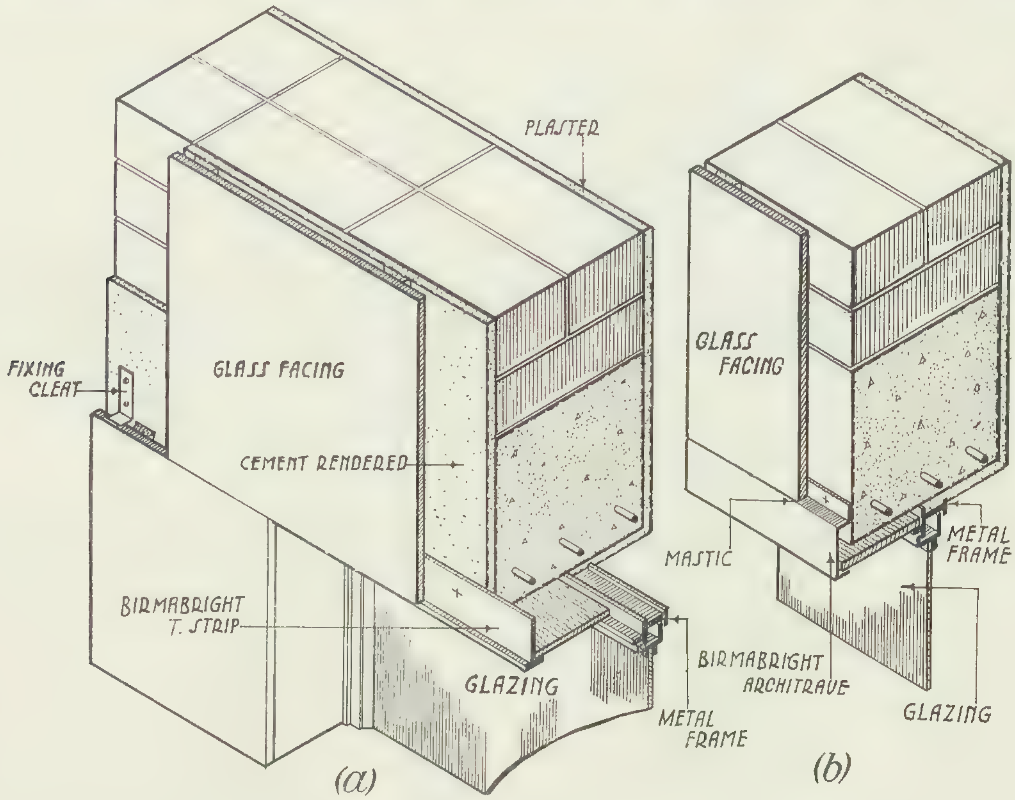

Fig. 73. Details showing the Construction over Openings in Glass-faced Walls
(a) Facings supported on metal tee strips. (b) Facings supported on metal architrave.

should be given a "fall" to the sides of the opening for the purpose of draining any moisture which may accumulate in the cavity over the opening. The construction of a brick soldier arch supported upon an angle section may also be seen in Fig. 34.

Figs. 73 (*a*) and 73 (*b*) are details through the head of a window opening in a glass-faced wall.

In Fig. 73 (*a*) the glass facings over the opening are shown supported upon a tee strip which spans the opening and is plugged into the reinforced concrete lintol. The glass soffit rests upon the flange of this tee strip and also upon a lug which is a part of the head of a metal window frame specially designed for this purpose.

Fig. 73 (*b*) shows an alternative suggestion. In this example the window opening is surrounded with a metal architrave which is attached to the walling material and forms a seating for the soffit slab and the facings.

Arches. There are various forms of arches and they are named according to the geometrical form of the arch curve, as for example, *segmental*, *semi-circular*, *semi-elliptical*, *pointed*, or *Gothic*, and prefixed according to the design or form. Apart from the question of craft, the chief concern in an arch is

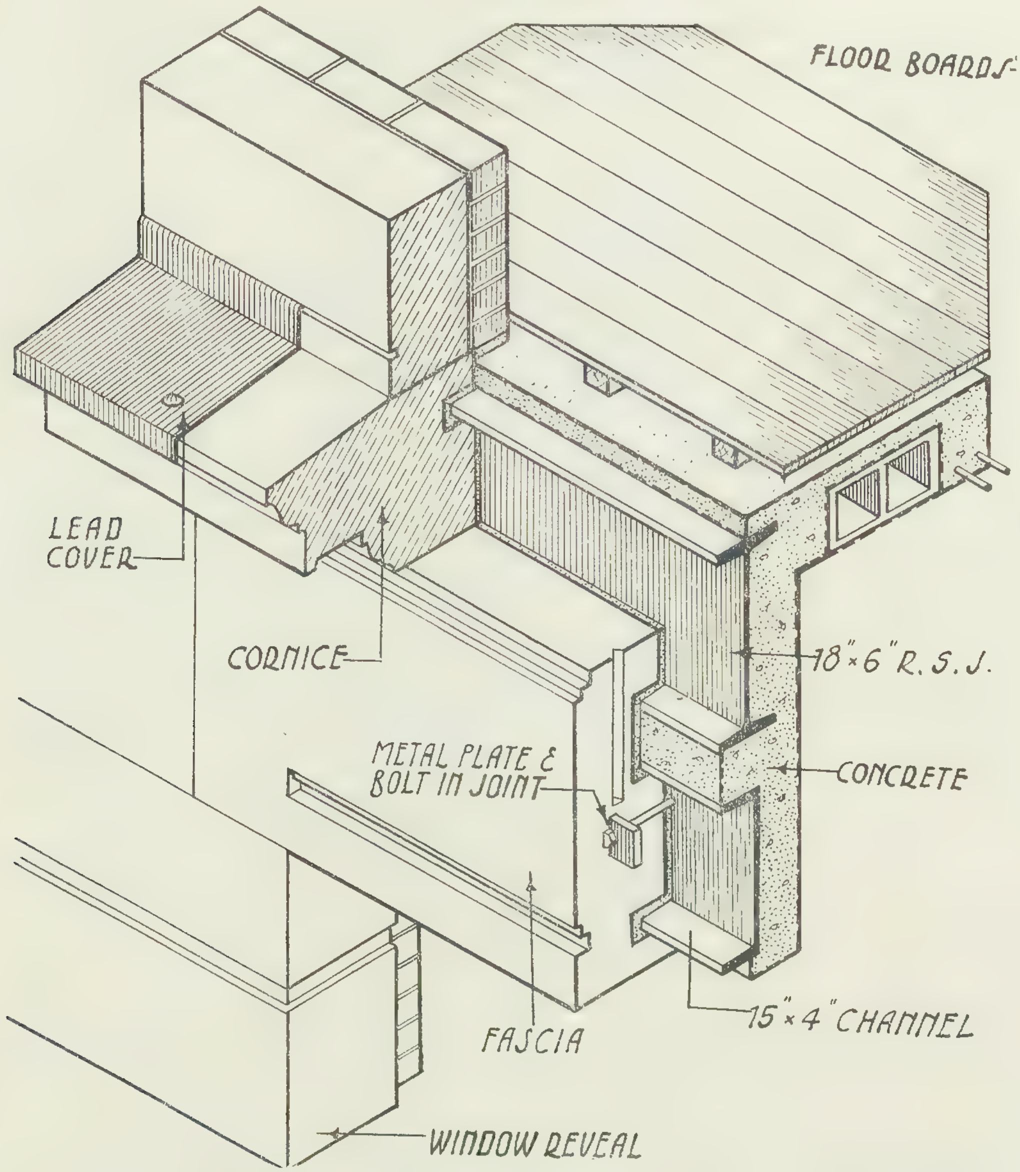

Fig. 74. Construction of Stone Fascia Course Attached to Steelwork

its stability, which is very largely dependent upon the methods adopted in its construction.

It is not intended to give a detailed list of the terms connected with the arch, or to describe the various methods of setting out its curves. All these may be obtained by reference to the many textbooks on building construction and geometry.

Fascia Courses. Before steel and reinforced concrete were used in building construction it was necessary to span large openings by means of arches. Now the spanning of wide openings with horizontal courses of stone or other

facing material is the usual practice, and the stone or material which forms the course is attached to structural members.

Such courses are known as *fascia courses*, and although the stones in such a course may be jointed to give the appearance of solid stones, they are really a veneer or covering to the structural members. The stones are usually attached to the structural members by some connecting device.

The method shown in the sketch, Fig. 74, is known as the *plate and bolt* method, and has many points in its favour. It is, for example, preferable to the

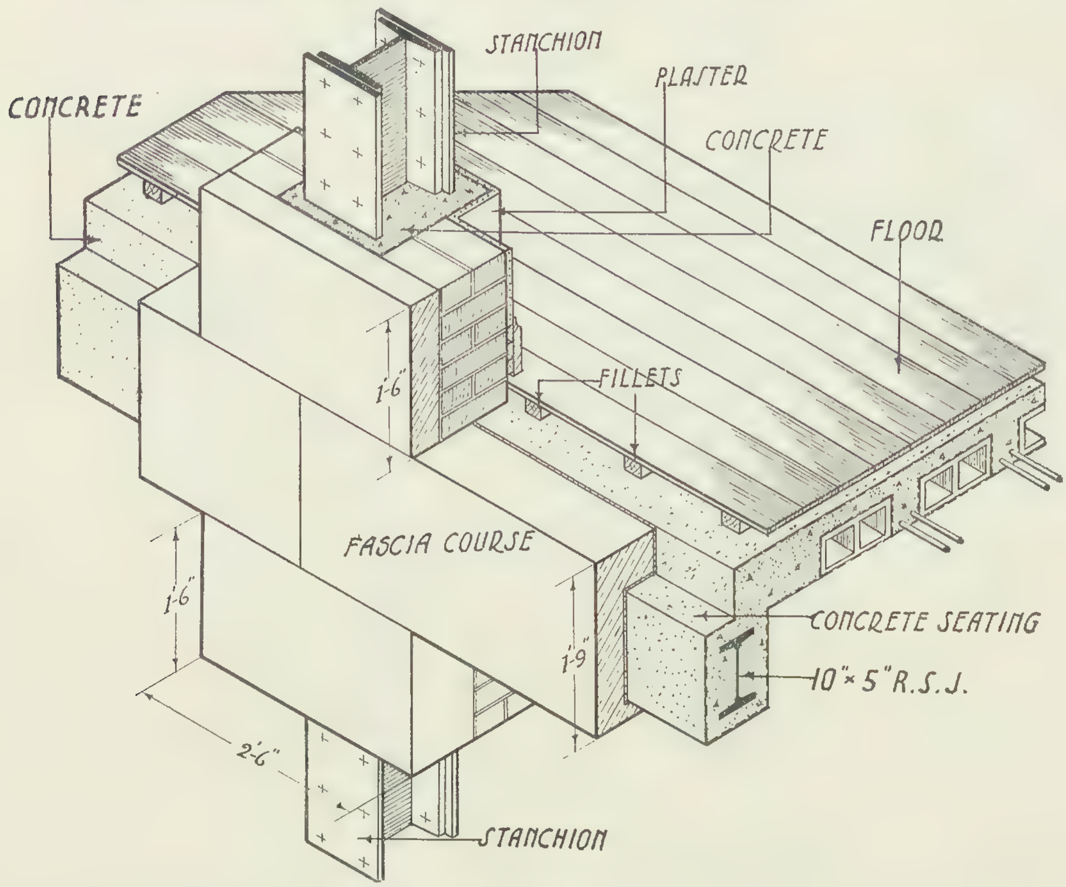

FIG. 75. STONE FASCIA COURSE SUPPORTED UPON THE CONCRETE CASING TO THE STRUCTURAL STEELWORK

use of rag-bolts or tee-bolts. A bolt is passed through the web of the girder and the plate is threaded on the bolt and fitted into a mortise which is cut into the joint surface of each stone. When the stones composing the fascia course are in position the joints between the stones are pointed and afterwards grouted with a cement mix which fills all the interstices between the metal connexions and the joint surfaces of the stone.

Buildings erected under the provisions of the *Code of Practice* are required to have all the structural members encased in concrete.

The application of this Code will necessitate a variation in the method of constructing facings and fascia courses, because the stones will have to be attached or supported upon the concrete casing instead of being connected direct to the steelwork.

A sketch showing the construction of a *fascia course* notched for and resting upon the concrete covering is given in Fig. 75.

Figs. 147 (*a*) and 147 (*b*) show a portion of the steelwork of a framed structure completely covered with concrete as required by the provisions of the Code.

Soffit Courses. When a fascia course has a deep soffit it is usual to form the soffit as a separate course of stones. To do this it is necessary to suspend the soffit course from the structural member. Sketches showing how this may be done are given in Figs. 76 and 77. It is usual to suspend soffit courses from the

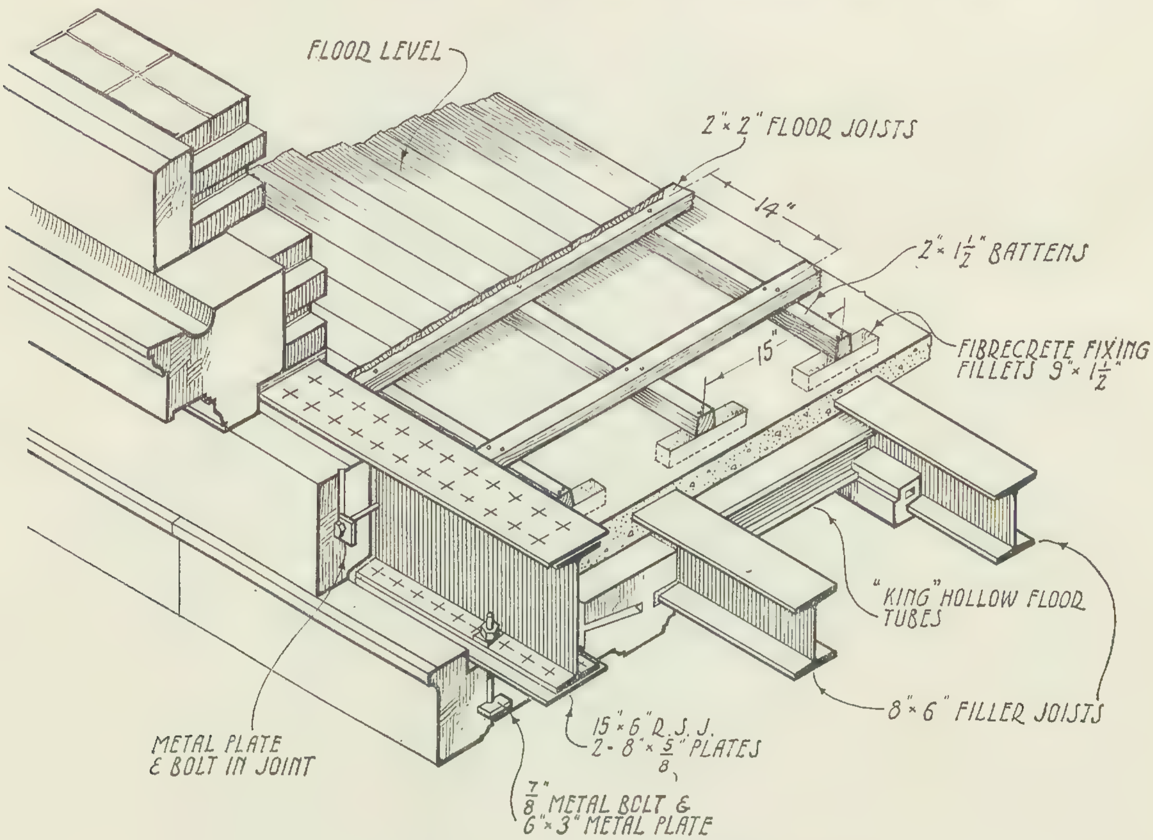

FIG. 76. STONE SOFFIT COURSE ATTACHED TO STRUCTURAL STEELWORK

structural steelwork by attaching the stones to the steelwork by means of metal plates and bolts which are inserted in the joint surfaces of the stones.

Cornice Construction. Walls of buildings are usually crowned with a cornice, which is composed of either wood, stone, cast stone, terracotta, brick, or brick faced with cement stucco.

Besides being an architectural feature, the object of a cornice is to protect the surface of the wall from excessive moisture; therefore whatever material is used a cornice should be so designed and constructed as to carry out this purpose. Rain-water may be kept clear of the face of the wall by forming a continuous drip in the detail of the cornice and as near as possible to the nosing of the cornice. Care in this respect will tend to prevent the occurrence of unsightly stains which may be seen on the façades of many buildings.

Cornices are sometimes surmounted with a parapet wall to lend the appearance of a counterbalance to the overhanging weight of the cornice. Also a roof

may rise direct from the top surface of a cornice; then it is usual to form a gutter for the conveyance of rain-water discharged from the roof on top of the cornice, or to substitute for the crowning member of the cornice a metal gutter which will thus act as that member. With the introduction of framed structures, cornice construction has changed.

Then the often repeated statement that the weight of the material on the wall should more than counterbalance the weight of the material projecting

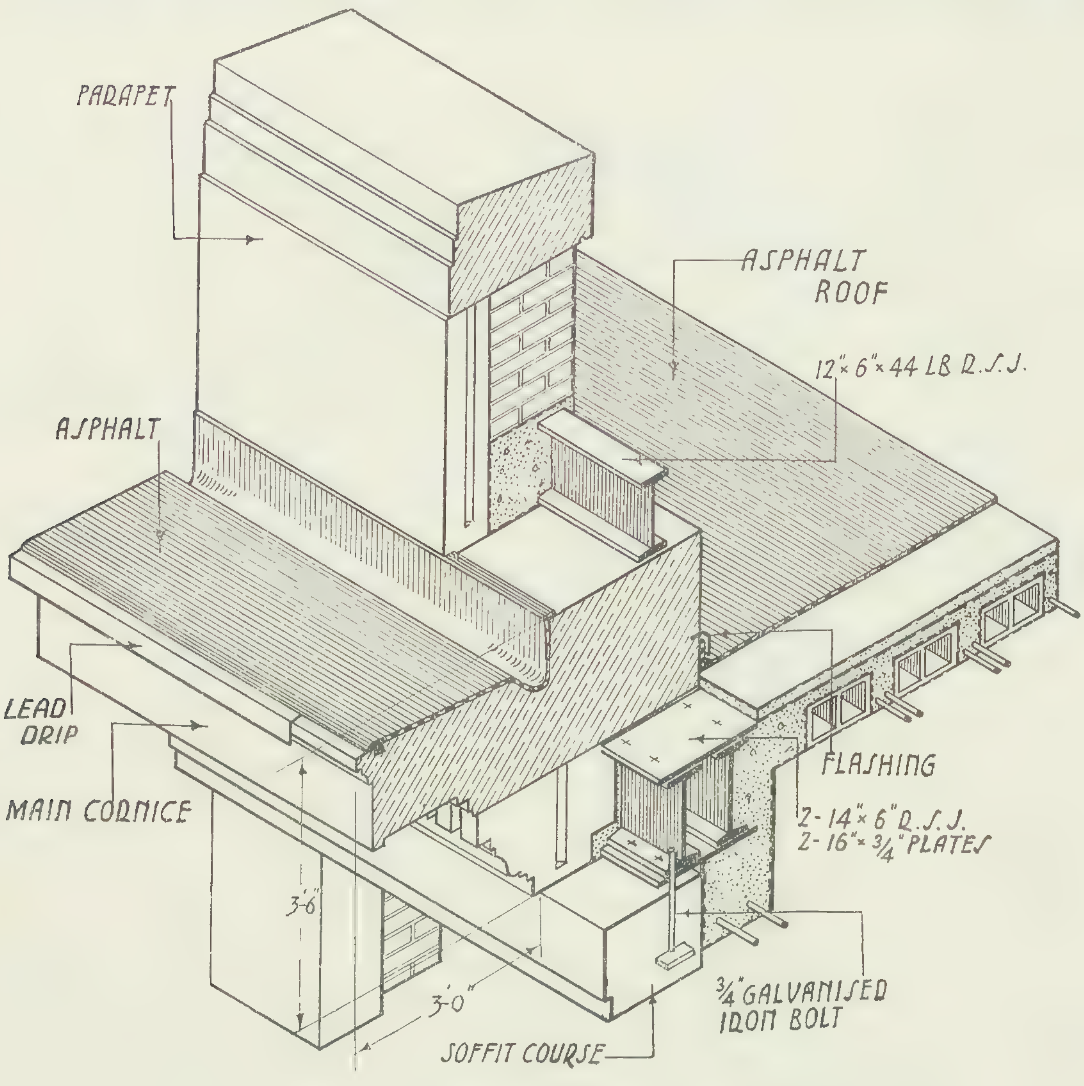

Fig. 77. "Built-up" Cornice and Soffit Course Construction

from the wall surface is not compatible with modern practice because such cornices are attached to and supported by the framework of the structure.

This method of construction permits a cornice to form the crowning member without being surmounted by a blocking course or counterbalancing weight.

The placing of steel cantilevers in the joint surfaces of the stones which comprise a built-up cornice is a method to be encouraged as a means of minimizing risks in the event of fire.

Stone cornices are often required to span very wide openings. Under such conditions the stones must be supported upon and attached to the framework

of the structure. A sketch showing the construction of a built-up stone cornice is given in Fig. 77.

In this example the cornice consists of a soffit or head course which is attached to or suspended from a boxed-up girder by means of metal plates and bolts which are inserted in the joint surfaces of the stones. The middle or dentil course is notched to fit into the web of the girder and rests upon the soffit course. The crowning course is bedded upon the boxed-up girder whilst the overhanging

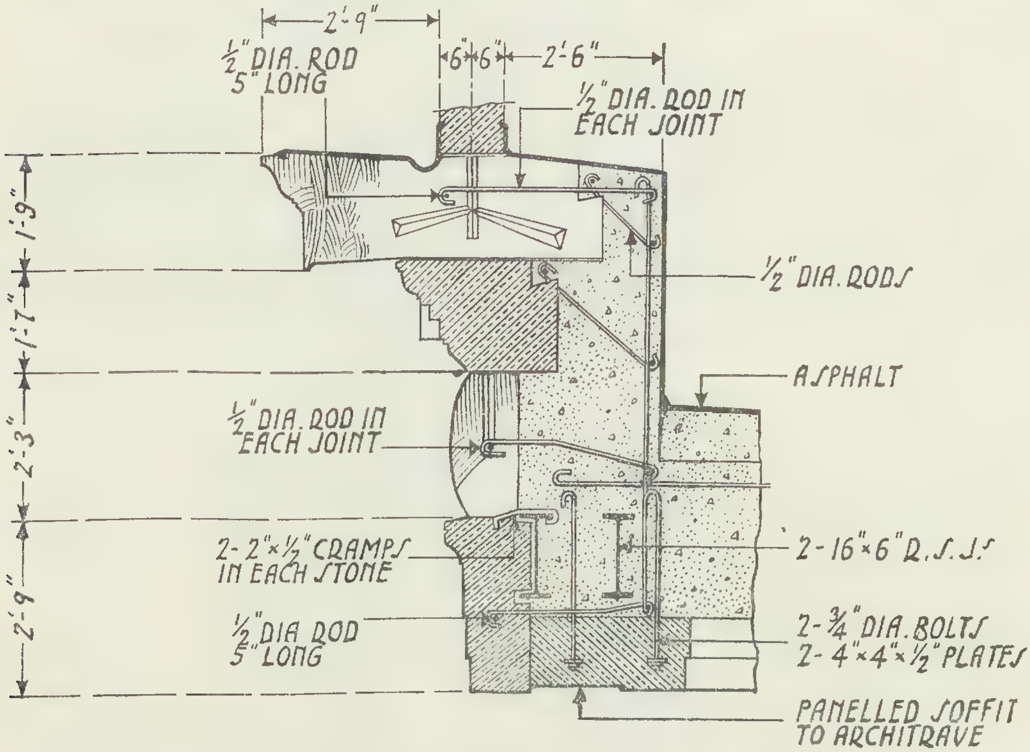

Fig. 78. Section Through an Entablature Attached to Reinforced Concrete

weight is counterbalanced by placing a R.S.J. immediately above the cornice, and a horizontal concrete beam is formed as shown in the sketch. The top exposed surface of the cornice is covered with mastic asphalt. A 4 lb. lead strip is fastened in a groove situated in the top surface and brought down over and below the nosing of the cornice to form an auxiliary drip.

Fig. 78 is a section through an entablature which includes the architrave, frieze, and cornice. It should be noticed that the whole of the entablature is connected to reinforced concrete by means of metal rods and hook-pin bolts, which are placed in the joints between the stones and attached to the steel reinforcement embedded in the concrete. The soffit course is suspended from the concrete, also the stones comprising the cornice have dovetailed recesses cut in the back surface of the stones. These act as a means of keying the stones to the concrete. In this instance the stones are placed in position before the concrete beam is formed.

Fig. 79 shows the construction of a stone cornice made up in two courses. A parapet gutter covered with mastic asphalt is formed behind a dwarf parapet wall and illustrates the finishing of a flat roof when the rain-water is to be discharged into a parapet gutter. A method of finishing a slab-faced wall is shown

in Fig. 80. The cornice or crowning course is secured to the structural steel, whilst the concrete at the back of the course forms a gutter for the collection and discharge of rain-water. The sketch also suggests a suitable method when a set-back of the wall face is desired at cornice level. Terracotta and faience are very suitable materials for use in cornice construction, chiefly because the blocks

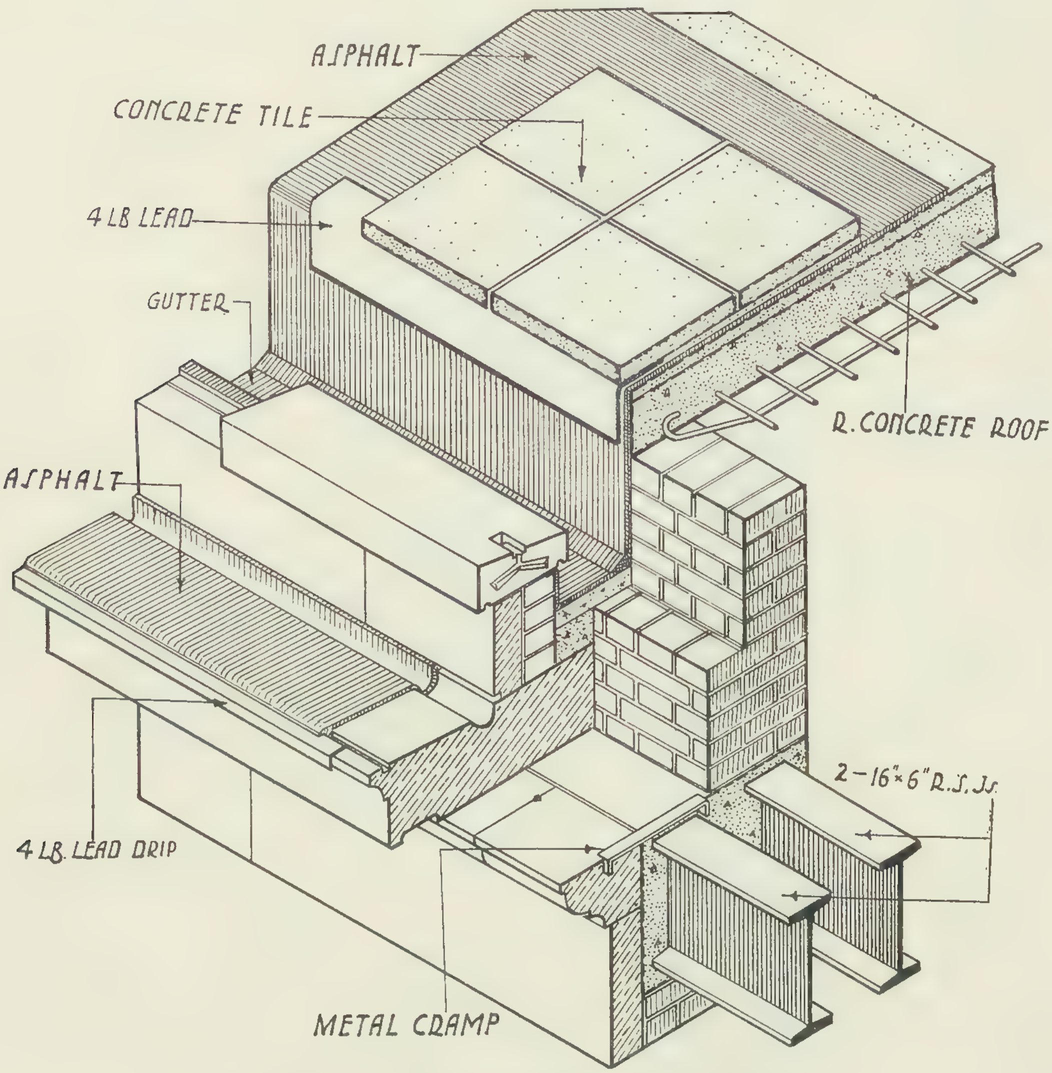

Fig. 79. "Built-up" Cornice Construction

can be easily attached to structural members, and the required sinkings can be cast during the making of the block.

Fig. 81 (*a*) explains the construction of a terracotta cornice, the height of which is complete in one block. Steel brackets are riveted to the web of the girder and spaced apart, so that they coincide with the joint surfaces of the cornice blocks. The sketch also illustrates the construction and method of supporting a flat arch over a window opening to the floor below the cornice. The blocks are attached to the steelwork by hook-pin bolts which are threaded through the web of the plated girder.

The construction of a terracotta faced pier also appears in Fig. 81 (*b*).

Another example of terracotta cornice construction is given in Fig. 82;

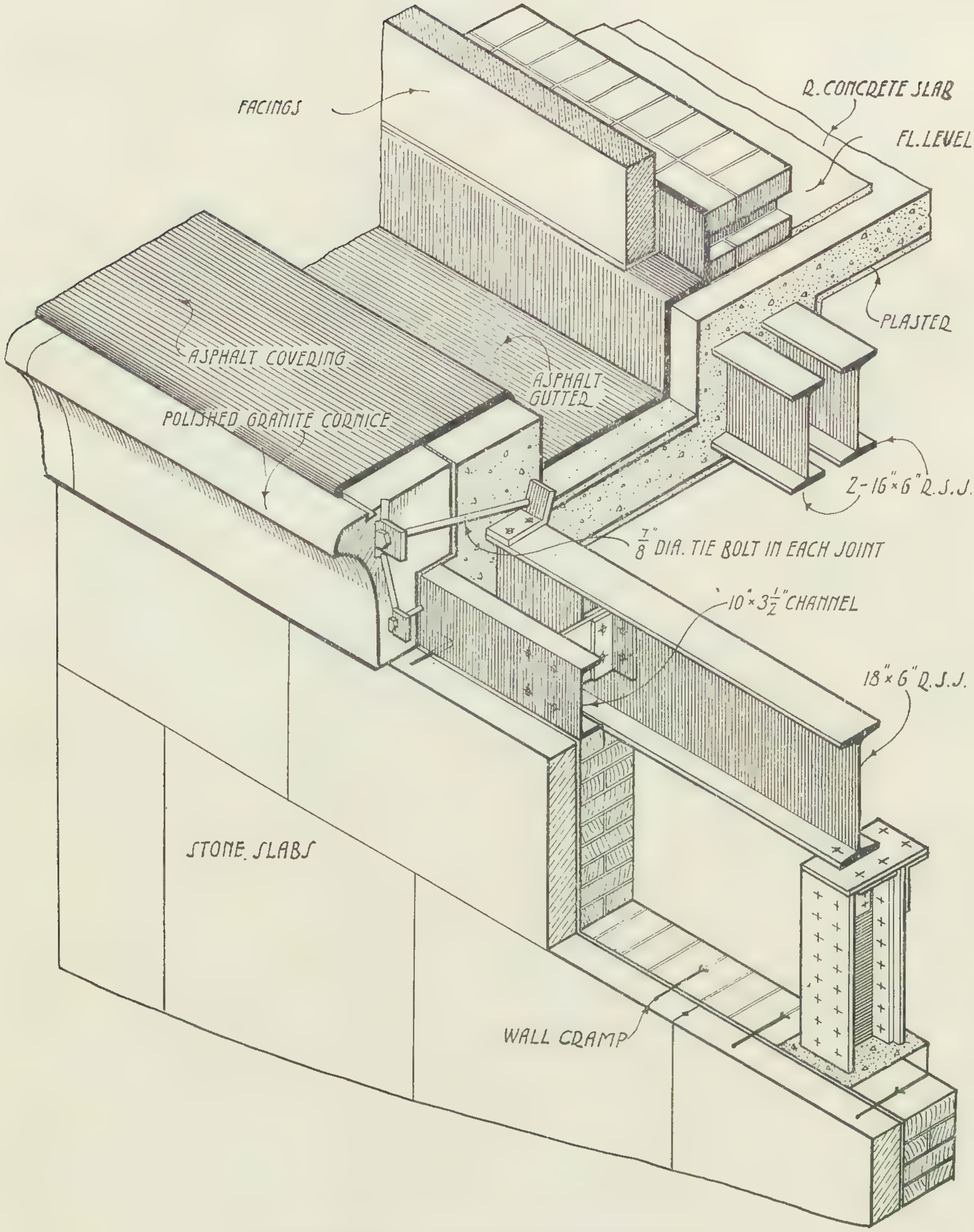

Fig. 80. Finish at Top of a Slab-faced Wall

but in this instance the height of the cornice is made up in three beds or tiers.

The bottom tier is suspended from angle sections placed side by side in pairs to coincide with the joint surfaces of the blocks and to act as cantilevers.

The angle sections or cantilevers are inserted in the joint surfaces of the middle

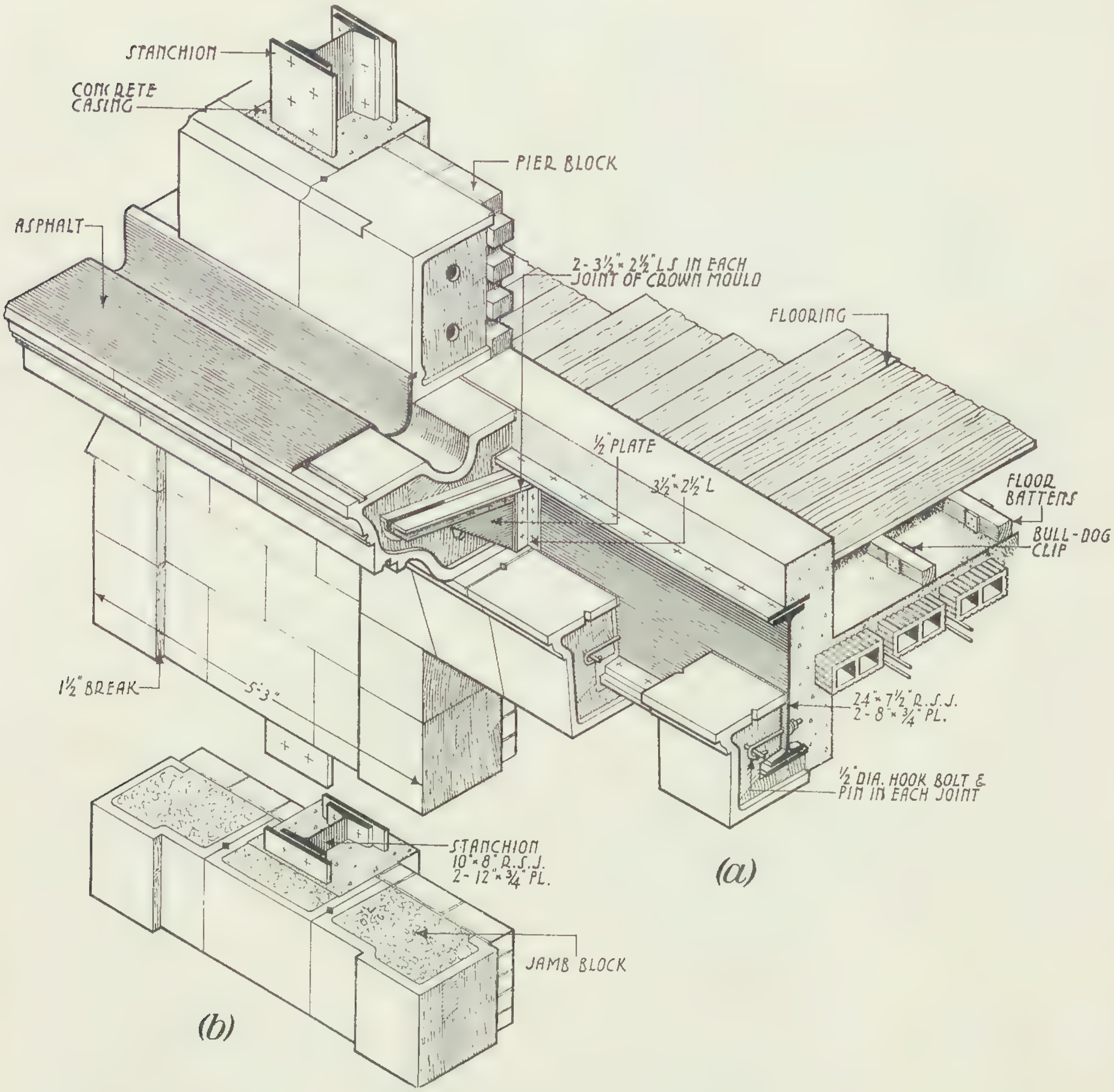

FIG. 81. CONSTRUCTION OF TERRACOTTA CORNICE AND PIER
(a) Detail of cornice. (b) Detail of pier.

course and the blocks comprising the top course are held in position by hook-pin bolts connected to the cantilevers. Faience slabs are shown facing the parapet wall.

In Figs. 83 (*a*) and 83 (*b*) may be seen details of terracotta facings, including a fascia course and cornice over a shop front. The fascia course rests upon an angle section riveted to the rolled steel beam which spans the opening. The space below this angle section provides room for the accommodation of the sun blind when rolled up and not in use. The sketch also shows how a window shutter

may be housed behind the rolled steel beam and secreted above the shop window ready to be brought into use when desired.

The construction of the pier for the shop front is shown in Fig. 83 (*b*).

If desired a cornice as a crowning member may be constructed with reinforced concrete, as a continuation of the roof slab, as in Fig. 84. In this example the top member of the cornice rests upon the front portion of the projecting concrete

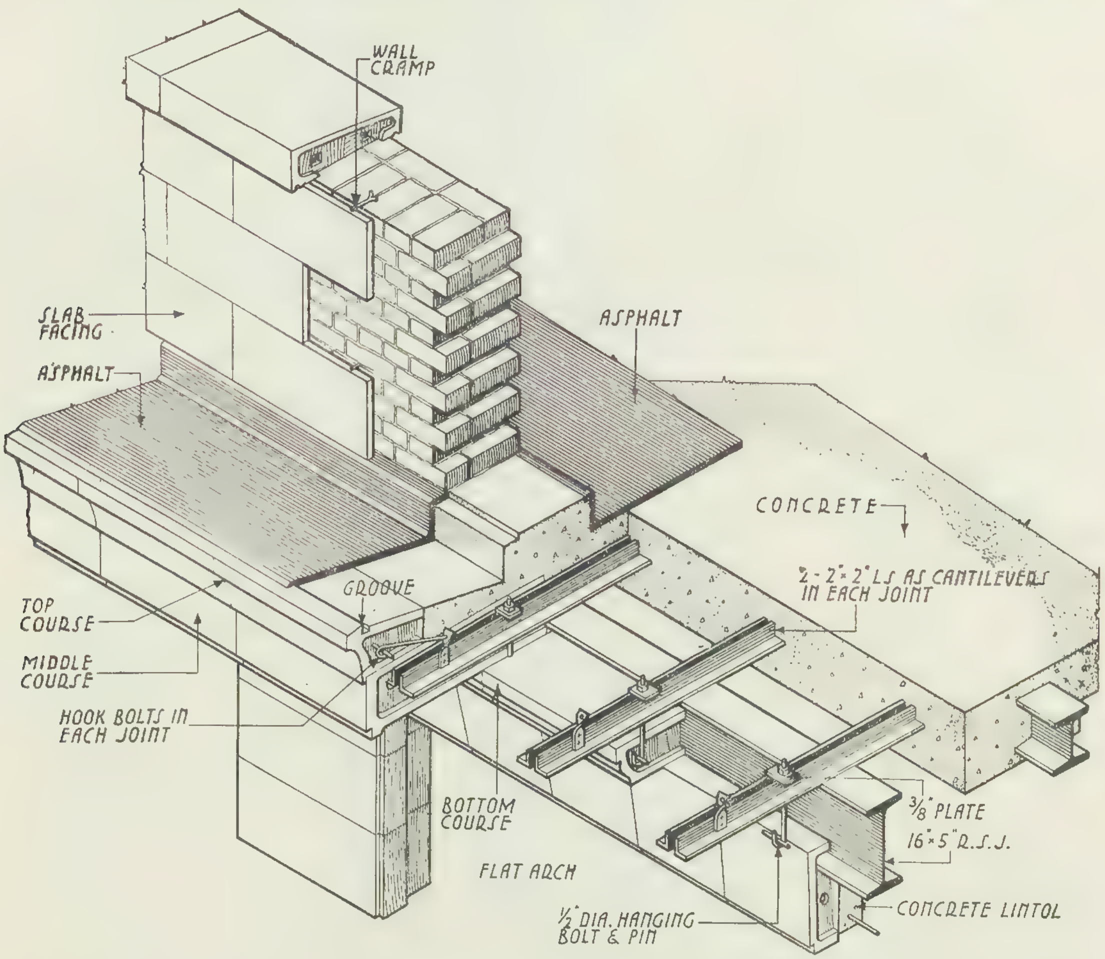

Fig. 82. Construction of Terracotta Cornice Supported upon Structural Steelwork

and forms the gutter which is afterwards covered with mastic asphalt for collecting and discharging rain-water from the roof surface.

Eaves. The construction of an eaves over a cavity wall is given in Fig. 85. A detail of this construction is given because of the diversity of opinion upon the best method of closing over the cavity at the top of this type of wall.

The loads of the roof may be thrown on to the inside wall or on to the outside wall if they are built for this purpose. But should the cavity wall comprise an inner and outer wall each $4\frac{1}{2}$ in. thick, it would be necessary to distribute the load over the entire wall area. This may be done by forming a 9 in. wall immediately above the cavity and recessing the face of the bricks $2\frac{1}{4}$ in. from the face of the wall. This recess will form a seating for the wood bearers which support the soffit board under the eaves. The wall plate should be placed flush with the

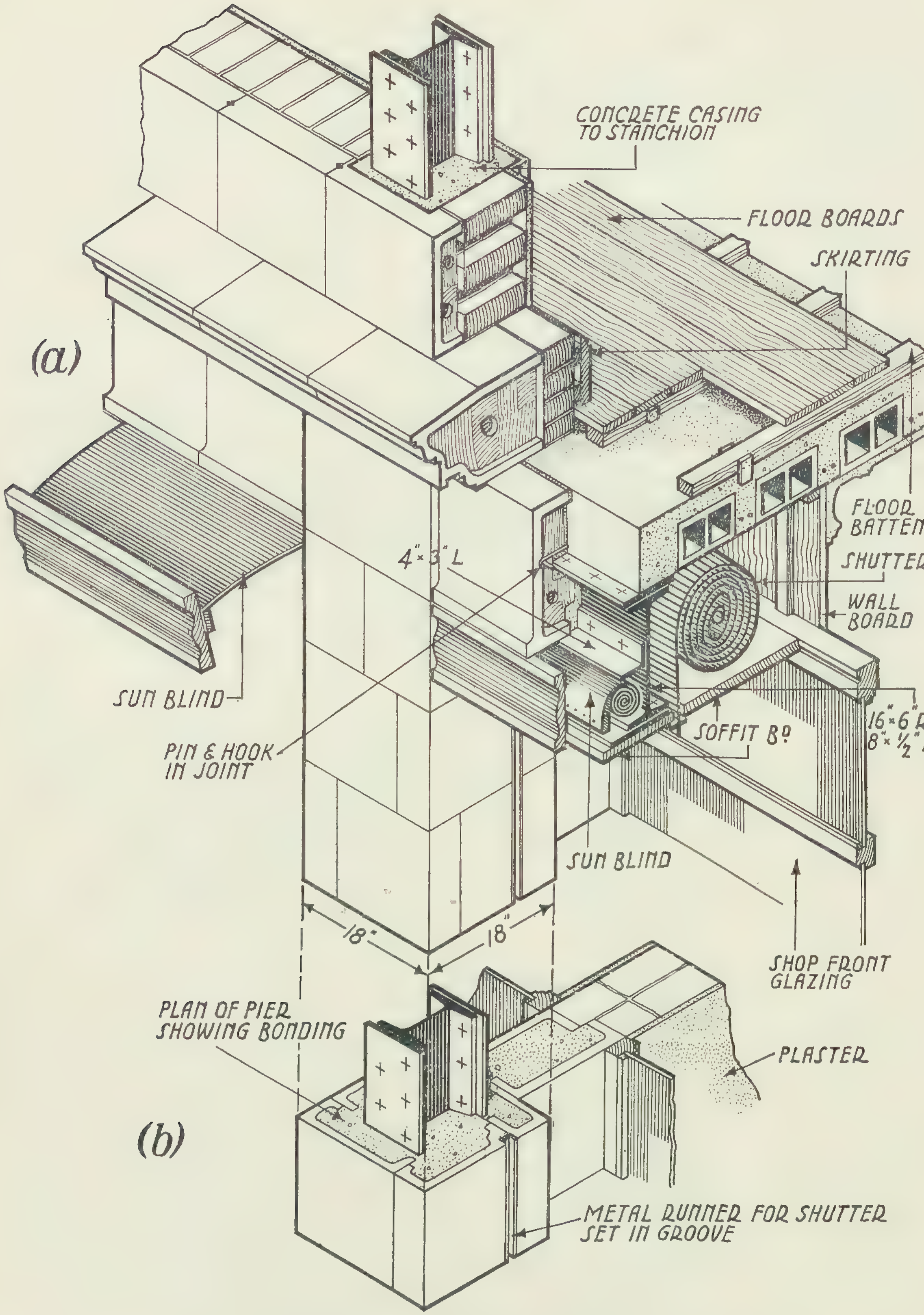

FIG. 83. CONSTRUCTION OF A SHOP FRONT FACED WITH TERRACOTTA
(*a*) Construction over opening. (*b*) Construction of pier.

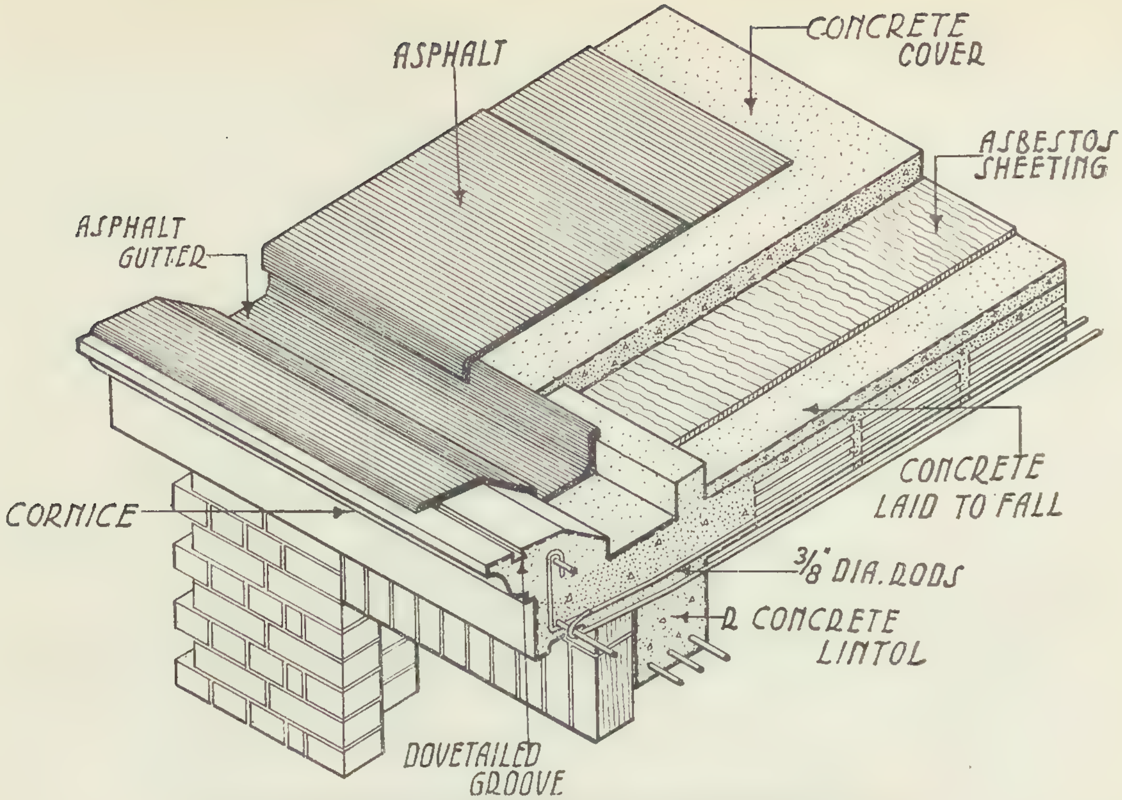

FIG. 84. REINFORCED CONCRETE CORNICE AND FINISH TO FLAT ROOF

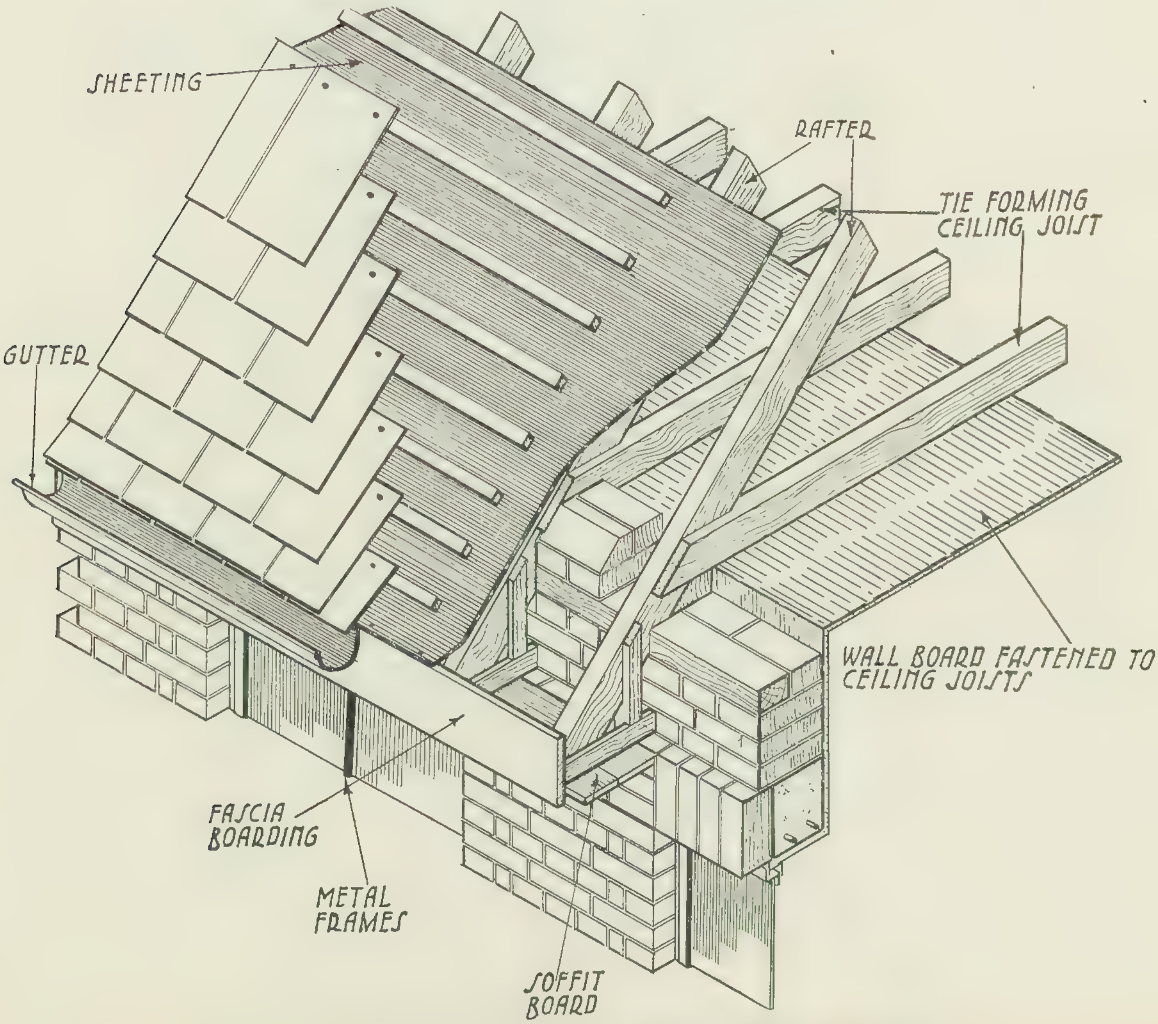

FIG. 85. CONSTRUCTION OF AN EAVES OVER A BRICK CAVITY WALL

front face of the 9 in. wall, and will in this position assist in distributing the roof loads along the entire length of the wall.

Fig. 86 shows how an eaves may be formed by continuing the concrete floor

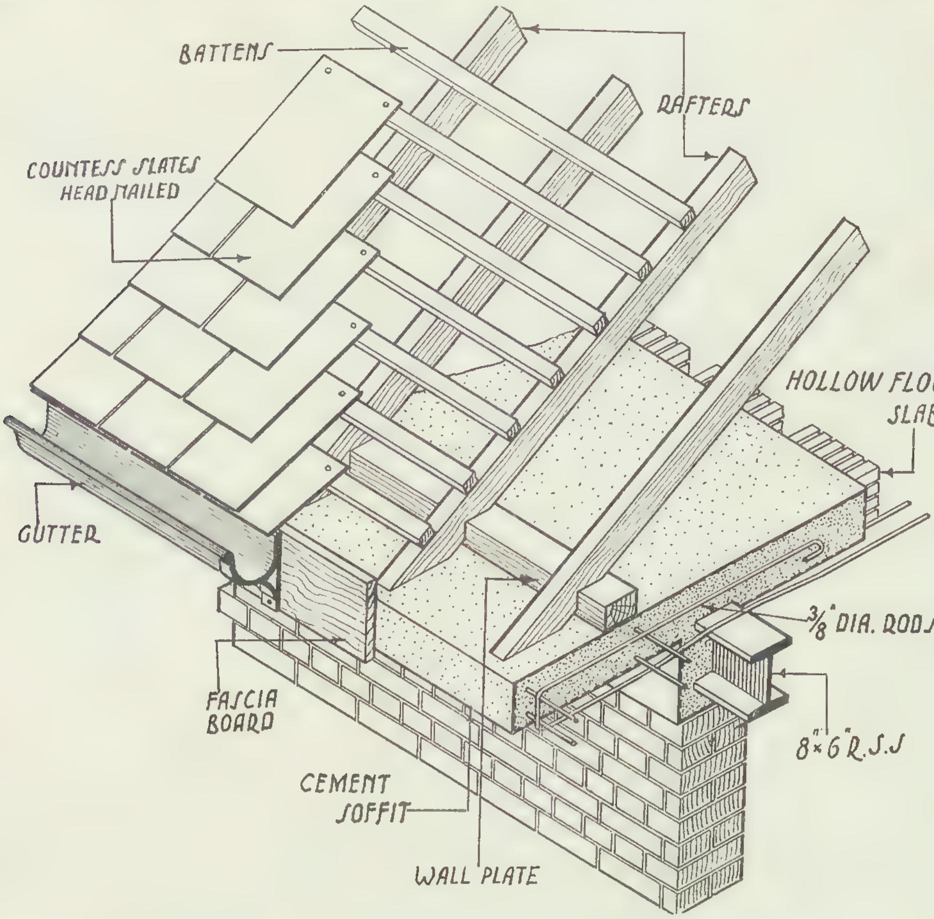

Fig. 86. Construction of an Eaves with Concrete Soffit

or roof slab beyond the face of the wall. This is a more modern method of forming an eaves when a pitched and slated or tiled roof is desired in preference to a flat roof. A wall plate is fastened to the top surface of the concrete slab and the rafters are connected to this in a similar manner to an ordinary timber pitched roof. The fascia board is fastened to the front edge of the concrete projection.

CHAPTER IV

DAMP-PROOFING

The rendering of a structure free from damp is one of the most important considerations in building construction; therefore methods of prevention must be employed in the construction of walls, floors, roofs, etc. Damp is always liable to penetrate the bases of walls and basement floors, even when they are constructed in well-drained or fairly dry ground.

Concrete ground floors are subject to damp penetration, hence provision must be made to prevent the transference of moisture from the soil through the concrete and into the room above.

Water pressure under basement floors may be relieved by placing surface drainage pipes over the site and under the floors. If this is done, moisture will be conveyed by these pipes and should be discharged or pumped into a drainage system. Concrete ground floors and basement floor slabs should be laid on a thick layer of broken brick or hard-core. If surface drain pipes are considered necessary, they should be laid within the thickness of this layer of hard-core. Concrete ground floor slabs also may be laid on hollow floor blocks as in Figs. 6 and 13.

The inclusion of these blocks under the concrete floor slab will greatly assist in keeping the underside of the slab well drained.

Whichever method is adopted for floors and walls, it is important that some form of damp-proofing be incorporated.

There are three methods of damp-proofing in general use and they may be described as follows.

Membrane Damp-proofing. This method consists of incorporating, in walls and ground floors, layers of impregnated felt covered with tar pitch, or layers of mastic asphalt.

The latter is generally considered the best method for the insulation of basement floors, bases of walls, retaining walls, etc., from penetration by damp. Fig. 5 shows how a concrete ground floor may be rendered damp-proof by the insertion of a layer of mastic asphalt immediately above the surface concrete and below the concrete floor slab. This layer is continuous with the damp-proof course that extends through the thickness of the wall.

Integral Damp-proofing. In this method certain compounds are added to the concrete during the process of mixing. The compounds may be in the form of liquid, paste or powder.

It is contended that by the addition of one of these compounds the concrete is rendered more impermeable because the voids in it become filled. As the success of the integral damp-proofing is dependent upon the filling or the elimination of those voids, it is essential that the added substance shall lubricate the granules of sand and other aggregates so that the particles are assisted into closer association with each other, and thus render the material more dense. Integral damp-proofing methods may be combined very successfully with membrane damp-proofing methods.

When used in very damp situations or for walls and floors associated with deep excavations or where a high head of water exists, the combination of the two methods will produce excellent results.

Surface Treatment. The walls are treated with a waterproof paint or else they are coated with cement mortar which has been integrally waterproofed. That is done by adding a predetermined percentage of one of the waterproofing compounds to the gauging water with which the Portland cement is hydrated.

The success of this treatment depends upon the complete filling of the surface pores of the material.

For covering exposed external walls and the surfaces at the base of walls, where the soil abuts against the wall, this method of damp-proofing may be beneficially used: but it will not be as effective as the application of a membrane layer which is put within the mass of the walling material.

In many instances, advantage may be obtained by super-imposing brickwork or concrete upon the surface layer. Then the method becomes similar to that described under "Membrane Damp-proofing."

The other form of surface treatment is the application of a waterproof paint to the surface of walls. This sometimes yields very beneficial results. Such treatment, however, is likely to spoil the natural appearance of the facing material.

The façades of many beautifully designed buildings are spoiled as the result of damp penetration through the pores of the materials with which the walls are constructed or faced. Dampness will thus travel and dry out on the wall surface in positions often far removed from the cause of infection.

These defects may be due to weather conditions during building operations. Again they may be traced either to the use of too much or of unsuitable water in the processes which combine to make the structure, or to faulty construction.

A judicious coating of the hidden surfaces of the facing materials with a bituminous solution will tend to lessen the damage caused by the movement of the moisture content in building materials, but such treatment will not exclude damp or prevent damp from penetrating into a building.

Damp-proof Courses. It is not a difficult problem to construct brick and masonry walls in a manner which will prevent dampness from rising into the walls. Care must be given to the inclusion of an effective damp-proof course in the walls.

The usual cause of dampness in walls may be said to be—

(1) the omission of a damp-proof course;
(2) the provision of an inefficient damp-proof course;
(3) the use of very porous walling materials;
(4) defective construction.

To be effective, a damp-proof course must extend through the entire thickness of the wall and should be composed of impervious material such as sheet lead, slates, bituminous felt, lead-lined felt, vitrified stoneware blocks, or mastic asphalt.

The damp-proof course for the base of an ordinary wall should be situated about 6 in. above the ground level, and continue unbroken throughout the entire length of the wall, irrespective of the changes in the level occasioned by a rising or falling ground level.

In the instance of ground floors constructed with timber, the damp-proof course should extend unbroken under the timber wall plates upon which the ends of the joists rest. When walls are built in conjunction with a concrete ground floor, the position of the damp-proof course should be level with the top of the surface concrete which covers the floor area.

The concrete floor should be formed immediately upon the asphalt layer which covers the concrete surface layer, or the concrete surface layer may act as the concrete floor as in Fig. 13.

This method is quite suitable in positions where there is no head of water; but if there is a slight head of water, the construction should be altered by embedding a layer of expanded metal reinforcement in the concrete as in Fig. 12.

The position for placing the damp-proof course in a cavity wall is shown in Fig. 28, which also illustrates the construction when a service duct is desired under the floor and parallel with the wall face. The provision of ducts in the position shown will assist very largely in keeping the wall dry and they can be used as a means of ventilating the floor and for housing drainage pipes, etc.

Open Areas. When ground floors are situated below the outside ground level they require special treatment in their construction to ensure the exclusion of dampness from the walls and floor.

This can be done by inserting the damp-proof layer over the floor area, continuing it through the thickness of the walls and up the vertical external faces of the walls, and turning it in to a joint about 6 in. above ground level.

If site conditions permit, an open area should be formed in front of the external wall by excavating the outside soil to a depth below the floor level, and constructing a small retaining wall built parallel with the face of the wall so as to support the earth, as shown in Fig. 6. Provision must be made for the drainage of open areas, otherwise they will prove of little use in preventing damp from getting to the inside of the building. When an open area is formed in front of an external wall the ground floor is treated in exactly the same way as when the floor is above the ground level.

In the sketch (Fig. 6) the damp-proof course is continued through the wall and over the floor of the open area and up the back surface of the retaining wall.

This method of construction is particularly suitable to positions where the ground around the building is very damp.

When the space necessary for an open area cannot be afforded owing to site limitations, a cavity may be formed in the thickness of the basement wall.

The inclusion of this cavity will be no guarantee that dampness will be kept clear of the inner wall because it is likely to become a receptacle for all kinds of debris and dirt accumulations; also because of the difficulty of ventilation owing to its position.

A better method to adopt is to coat the outside surface of the wall with two layers of mastic asphalt and to protect these layers by building a $4\frac{1}{2}$ in. brick wall against the asphalt layers; then the adjoining earth will rest against the brickwork.

Basement Floors. The prevention of damp penetration through basement and multiple basement floors necessitates special consideration in their construction, because of the pressure exerted by the high head of water which is frequently encountered in deep excavations. Special provision has to be made in the construction of concrete foundations and retaining walls so that they will resist this pressure effectively. This resistance may be obtained by using mass concrete in their construction.

The concrete may be rendered waterproof by adding one of the waterproofing preparations to it during mixing. Whilst these waterproofing agents are exceedingly suitable for some purposes, it is better generally speaking to incorporate a

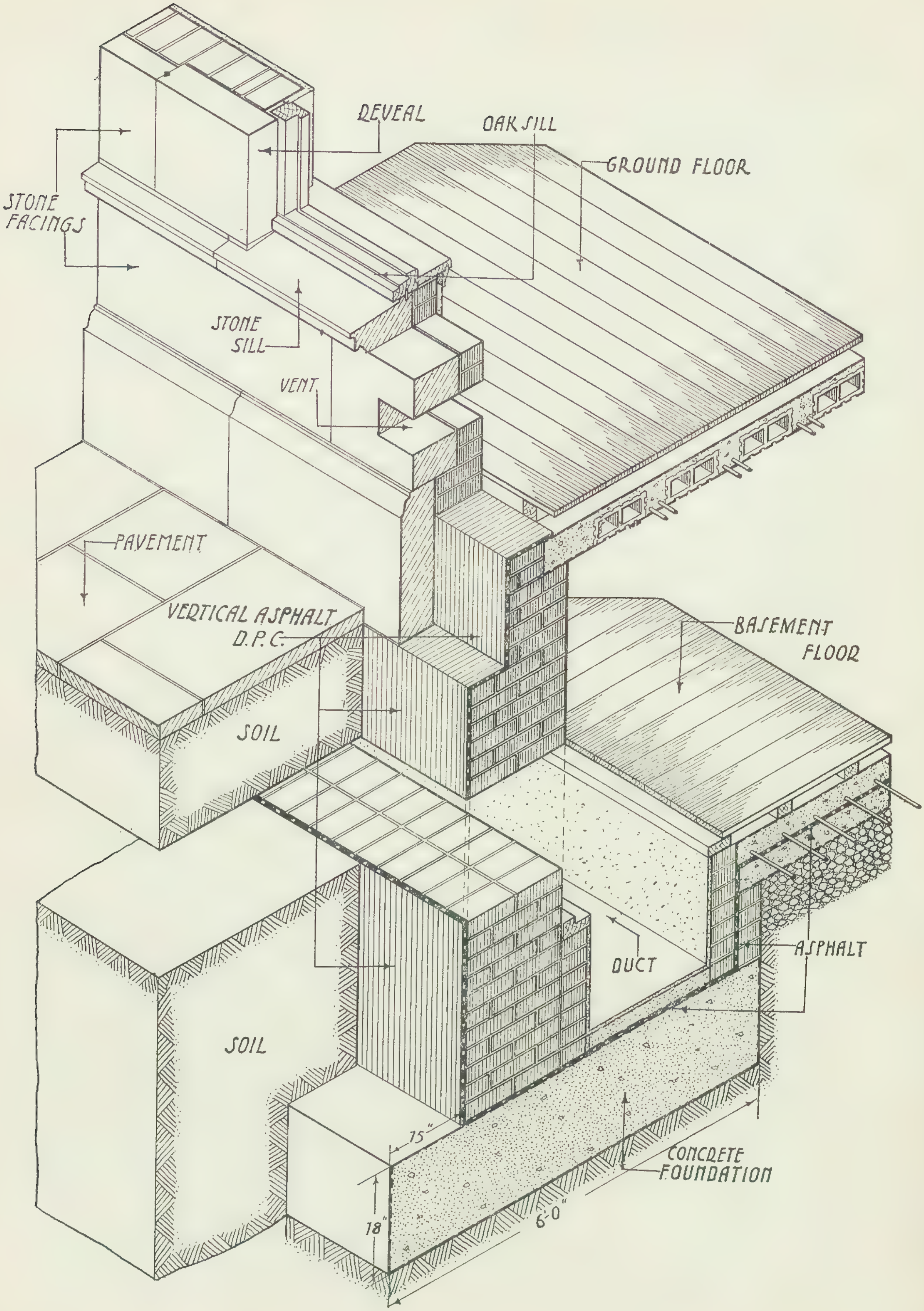

FIG. 87. DAMP-PROOFING BASEMENT FLOOR AND WALLS

double layer of mastic asphalt in retaining walls and floors rather than to rely simply upon increased thickness and the waterproofing of the concrete.

In single basement floors where, because of limited conditions of the site, the earth rests against the external walls, damp-proofing may be effected by placing a continuous damp-proof course in the position shown in Fig. 87. The asphalt damp-proof course extends in an unbroken layer over the whole of the floor area, through the wall foundations, and up the external vertical wall face to the pavement level.

To prevent the damp-proof course being exposed at the base of the stone-faced wall it is turned into the wall and continued horizontally under the bottom course of stone and vertically within the thickness of the wall up to the ground floor level. Here it is continued horizontally to the inside face of the wall.

Multiple basement floors may be insulated from dampness by forming a reinforced concrete tank over the whole of the site and inserting a membrane layer of mastic asphalt within the thickness of the concrete. The building will be then erected within this tank. The retaining walls will form the sides of the tank, and the reinforced concrete raft the bottom of the tank. The sections of retaining walls illustrated in Figs. 24 and 25 show the best position for these layers.

It will be noticed in each example that the damp-proofing course is, continuous throughout to the height of the retaining wall and over the floor area, where it is situated as near as possible to the bottom of the concrete floor slab.

In forming the bottom of the proposed tank it is usual to place a layer of concrete over the site and then cover it with two layers of mastic asphalt. The reinforced concrete raft should then be completed by placing another layer of concrete on the asphalt. This top layer is reinforced with steel bars and the floor proper formed after the superstructure of the building is erected.

Insulation of Stanchion Bases. Stanchion bases require to be insulated from dampness in the same manner as walls and floors.

Reinforced concrete foundations under steel stanchions should be interlined with layers of mastic asphalt, as shown in Fig. 9.

When the concrete foundations for a steel stanchion are continuous with the concrete foundations and footings of a wall the damp-proof course may be arranged as shown in Fig. 88. It will be noticed that the asphalt is continuous under the stanchion base and through the thickness of the wall.

It is advisable to protect the steel reinforcement bars in concrete foundations from corrosion. This is likely to occur if dampness is allowed to come into contact with the steel by penetrating the concrete. Reinforced concrete foundations may be insulated from dampness by introducing an asphalt layer in the concrete, as already noted in Fig. 9.

Damp-proofing Walls. Dampness not only occurs in a building through the medium of the soil: sometimes it is to be attributed to the effects of driving rains soaking into porous walling materials.

Preventive measures may be adopted by coating the external face of the wall with a waterproofing solution or paint, or by rendering the outside surface with cement and sand. In this way a cement stucco facing is formed which has been integrally waterproofed.

Insulating Roofs. Dampness in buildings can be caused by leaking roofs or faulty roof construction.

Generally speaking, pitched roofs are not as likely to allow dampness to penetrate into a building as flat roofs. But the covering material of pitched roofs is more likely to become broken or dislodged. On the other hand, flat roofs require special structural care if they are to fulfil their proper function. If flat roofs are constructed correctly and the right material used, there is no reason why they should be more liable to suffer from damp penetration than pitched roofs.

As most flat roofs are surrounded by parapet walls it is at the junction of these

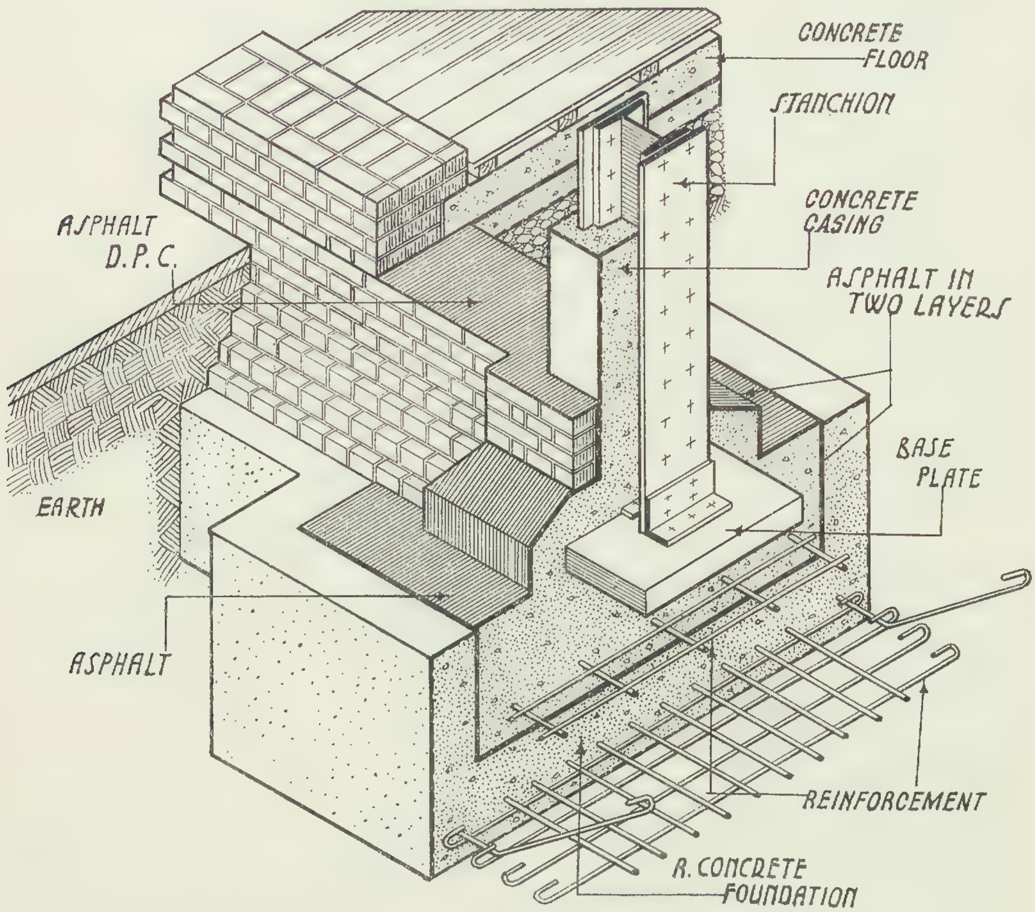

FIG. 88. INSULATION OF STANCHION BASE AT THE JUNCTION WITH BRICK EXTERNAL WALL

walls that faults most frequently occur. These are due chiefly to the effects upon roofing materials of extreme variations in climatic conditions. In very hot weather bitumastic roof covering retains heat to such a degree that there is considerable expansion of its particles. Further, this material may also be subjected to heavy rains. This will cause contraction of the particles. Fractures are bound to occur somewhere in the roof surface with these alterations of heat and damp. Its most vulnerable point is where it joins the parapet wall.

To prevent this failure, the roofing material should be put together as a unit separate from the flashing material, as in Fig. 89. This arrangement will allow the roof covering to expand and contract freely without interfering with the flashings. It will ensure as well a covered joint irrespective of the amount of expansion and contraction of the roofing material.

The insulation of roofing materials from heat absorption is described in the

section dealing with the construction of flat roofs, and illustrations are given showing how bitumastic roofing materials may be insulated by covering them with slabs of precast stone or similar material.

When bitumastic roofing surfaces are insulated in the manner just described, the flashings may be made continuous with their material.

Damp will also find its way into a building through the medium of the material with which parapet walls are built, and through the passages formed by

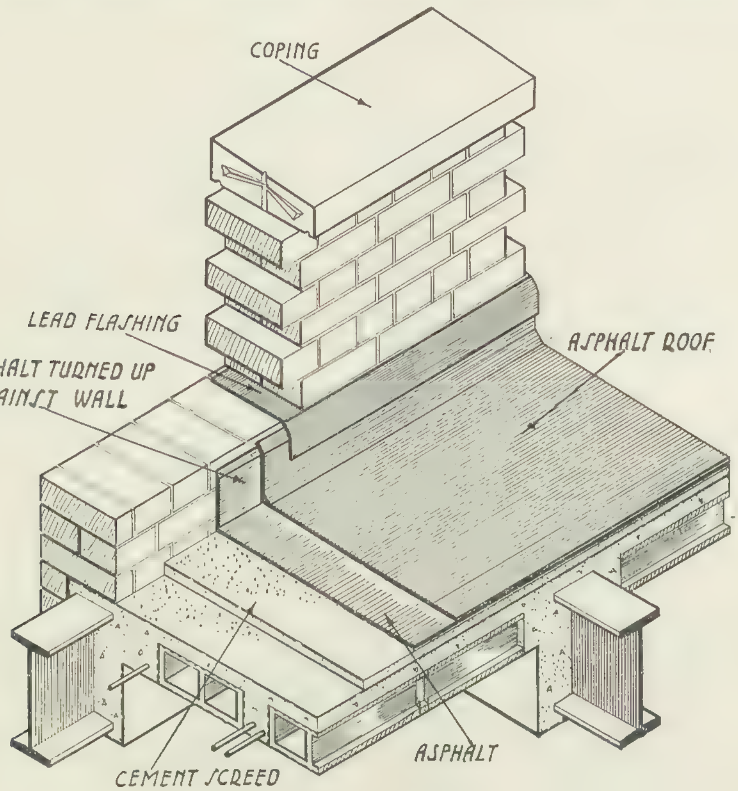

Fig. 89. Construction of Flashings to Flat Roof

minute cracks and badly filled-in joints, unless provision is made to prevent this defect.

A horizontal damp-proof course should be placed through the entire thickness of the parapet wall in a position above the roof surface, and preferably level with the turn-in of the flashings; thus by increasing the width of the damp-proof course material, the flashing may be formed in a continuous layer with it, as illustrated in Fig. 89.

Damp-proofing Terraces. Set-backs or terraces in the elevation of a building are characteristic features in modern architecture. Their construction calls for special attention, especially in forming an impervious covering to that portion of the building situated immediately underneath where the set-back occurs.

Much trouble is often occasioned by damp penetration at these points through faulty construction. Because main cornices are placed usually at the extreme permissible height from the pavement level, it is just above them that these set-backs usually occur. It is essential that the construction at these points shall keep rain-water from the rooms beneath.

If this is done well there seems to be no better material than mastic asphalt for rendering these positions damp-proof.

Illustrations showing suitable construction at these points are given in Figs. 46 and 80. For the covering of a reinforced concrete gutter which is to collect the rain-water from a glazed roof light, see Fig. 109.

CHAPTER V

CONSTRUCTION OF FLOORS

The fundamental object of building construction is to provide walls and roof for shelter, and floors to support the occupants and their possessions.

The floors therefore are one of the principal features of a building. The modern tendency is to provide some form of fire-resisting floor rather than timber floors, except in dwelling-houses.

There are several systems of floor construction and many varieties of floors. They are classified according to the types of beams which support their finishings and whether they are composed of timber, steel, or concrete thus—

(1) Wood beams or girders.
(2) Steel girders and wood joists.
(3) Steel girders and steel filler-joists encased in concrete.
(4) Steel girders and reinforced concrete slabs.
(5) Steel girders and hollow blocks in combination with reinforced concrete tee beams.
(6) Reinforced concrete slab floors and reinforced concrete tee beams.
(7) Precast concrete tee beams.

Floors are also classified according to their position in a building—

(1) Basement floors.
(2) Ground floors.
(3) Upper floors.

Construction of Basement Floors. It has been found in the section on "Damp-proofing" that one of the most important considerations in the construction of basement floors is the elimination of dampness.

When the ground is normally dry and well drained the earth should be excavated for some distance below the bottom of the concrete floor level and replaced with hard-core. Where possible the earth adjacent to the outside wall should be removed and an open area constructed, see Fig. 6. The open area should be drained by covering its floor with an impervious material which should be laid to a fall, and providing gullies at intervals throughout its length, connected to the drainage system.

When surface water is exerting an upward pressure, that is, when there is a head of water, the concrete composing the basement floor slab should be reinforced with steel. This reinforcement should be calculated to resist that pressure and placed in the concrete where it will be effective. If no reinforcement is used the thickness of the concrete may be increased.

Concrete slabs for basement floors should be constructed in two distinct layers; the lower slab or surface layer being placed direct upon the hard-core filling, and the upper slab laid upon the surface layer, after it has been covered with two layers of mastic asphalt as in Fig. 87.

Construction of Ground Floors. It is usual in house and light frame constructions to form the ground floors upon wood joists, that is, with timbers placed on edge and set from 12 in. to 14 in. apart, centre to centre. These timbers act as beams and support the floor finishings.

The ends of the timber joists are usually supported on timber wall plates

which rest upon the brickwork. Intermediate supports for the joists may be obtained by building dwarf walls known as *sleeper walls* from the surface concrete. The provision of these supports will shorten the span and allow the use of joists of less depth. A detail showing the construction of a timber ground floor and sleeper wall is given in Fig. 90.

In the building of sleeper walls provision should be made to allow for a free current of air to pass under the floor. This is done by omitting bricks at intervals

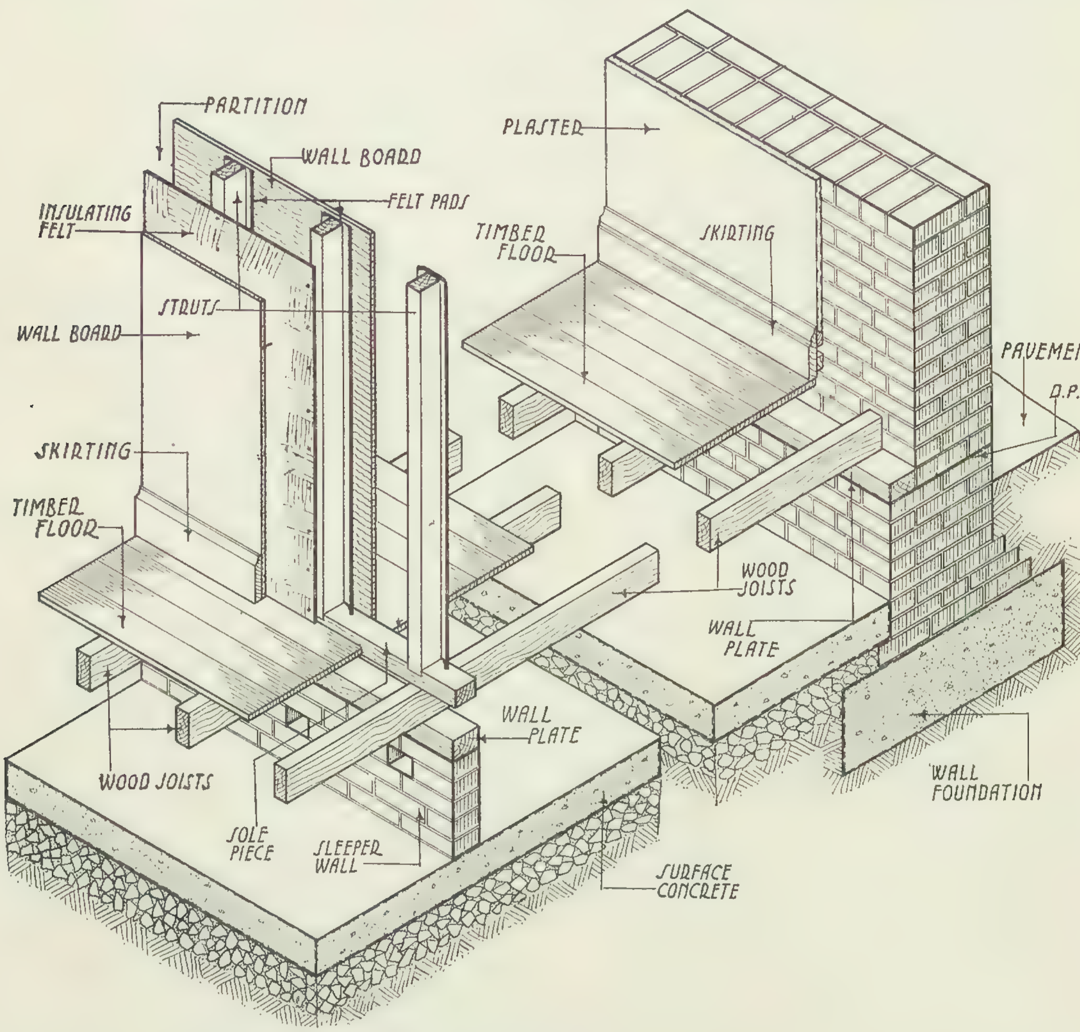

Fig. 90. Construction of Timber Ground Floor with Sleeper Wall and Timber Stud Partition Wall

throughout the wall, and encouraging the flow of air under the floor by inserting a generous number of air bricks in the external walls just below the floor level.

Dampness is kept from the floor timbers by placing an efficient damp-proof course under each supporting course, and by covering the whole of the floor area with a bed of concrete, known as a *surface layer*.

Modern practice in floor construction is to substitute concrete floors for timber floors, and where they are correctly constructed and the moisture kept away from the floor finishings, they can be more effective than timber floors. Fig. 5 shows the construction of a double slab concrete ground floor. If the ground floor is

relatively damp a good method is to form the surface concrete on the top of a layer of hollow floor blocks which are placed upon hard-core, as in Fig. 13.

The construction of the floor finish is of great importance. If floor boards are bedded direct on to the upper surface of the concrete, either by means of a mastic solution or a bituminous material, they will be liable to early decay through attack by dry rot. The floor boards should be laid on wood battens which have been previously impregnated with a preservative solution. The battens are fastened to the concrete floor by nailing or by means of one of the many forms of patent clip which can be obtained for such purposes.

If the floor is finished in one slab which is covered with asphalt, the battens should be bedded in pitch and tar and placed direct upon the asphalt as in Fig. 13. They should not be nailed or fastened in any other way. The spaces between the battens should not be filled with concrete.

It is advisable to cut small notchings in the bottom portions of the battens. This will assist in ventilating the space under the floor boards, especially if direct contact can be made with air ducts formed in the thickness of the walls.

The floor boards should not be grooved and tongued, and not tightly jointed.

It is inadvisable to cover such floors with thick linoleum.

Details given in Figs. 6, 10, 12, 13 and 14 call attention to the various forms of finishings to concrete ground floors.

Construction of Upper Floors. Timber is still being used in the construction of upper floors in domestic buildings, also in various types of industrial buildings. This material is cheap and easily erected and fulfils the requirements of good floor construction. Timber floors may be rendered rigid by the general use of a system of herring-bone strutting, as in Fig. 91. Also such floors may be sound-proofed by including various sound-proofing materials in the floor finishings. Timber upper floor construction consists of wood joists sufficiently stiff to prevent sagging, set on edge from 12 in. to 14 in. apart, centre to centre, and supported at each end on wall plates.

The floor boards may be fixed to the top edge of the joists and the underside finished by forming a lath and plaster ceiling as in Fig. 70.

A built-up floor finishing may be adopted and the ceiling suspended from the floor joists. The ceiling may also be formed with one of the many pressed fibre board sheetings and attached to the underside of the floor joists.

Sound-proof floors will be dealt with under the section on "Sound-proofing."

Steel and Timber Floors. Whilst steel and timber may be combined in the construction of the floors of a framed structure the structure cannot be classified as fire-resisting, nor can the floor be classified as a fire-resisting floor.

In this type of floor the timber joists will rest upon the top flanges of the steel floor beams, or be notched to fit into the web of the rolled steel beam as shown in Fig. 91.

Here is shown a timber upper floor combined with a light steel frame—a method which suits a semi-permanent structure. The external walls are made of hollow blocks and the ceiling of the room below the floor of sheets of pressed fibre board. The sketch also shows a wood casement window in a hollow block wall complete with finishings.

Fire-resisting Floors. The advent of framed structures has brought about many changes in the construction of floors.

Although no building material can be said to be absolutely fireproof, yet with

careful design and the choice of suitable materials a building can be constructed so as to be reasonably fire-resisting against almost any contingency. The prevention of the vertical spread of fire depends to a very large extent upon the fire-resisting properties of the various floors.

Reinforced Concrete Slab and Beam Floors. Reinforced concrete floor slabs should be continuous over the supports; or a system of floor beams, placed at intervals, should be introduced if the area to be covered is an isolated one.

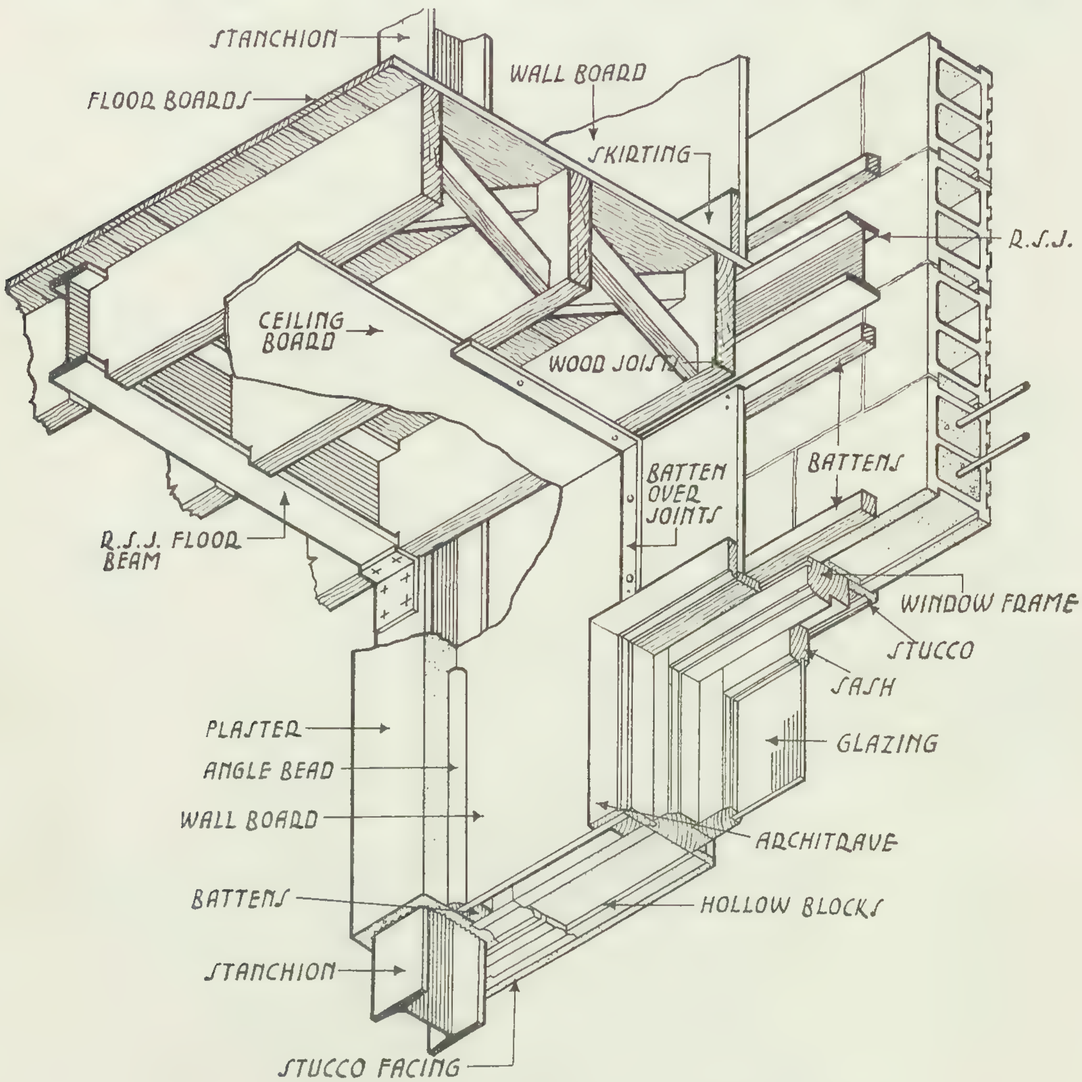

Fig. 91. Steel and Timber Upper Floor Construction showing Herring-bone Strutting

It is desirable to set the slabs continuously, either with beams or over the supports as this lessens the value of the bending moments, since a portion of the floor slab on either side of the beam is cantilevered out from the beam.

For the same reason the centre portion of a floor slab may be omitted without weakening the slab.

Reinforcement. Steel reinforcement bars are placed in concrete to take the tensional stresses.

It is common knowledge that when a beam supported at each end is loaded,

there is a tendency for the beam to bend. The fibres in the upper part of the section of the beam are in compression, whilst those in the lower half are in tension; and the greatest stresses occur at the extreme top and bottom of the section.

As concrete is weak in resistance to tensional stresses, the steel bars should be placed in the concrete in positions where those stresses occur.

To realize the function and purpose of steel reinforcements, it is essential that the adhesion between the steel and the concrete be thorough. If any slipping should occur between the two materials the concrete will be subject to tensional stresses.

Because of this many patent forms of reinforcing bars have been manufactured. These patent bars are provided with projections or irregularities which

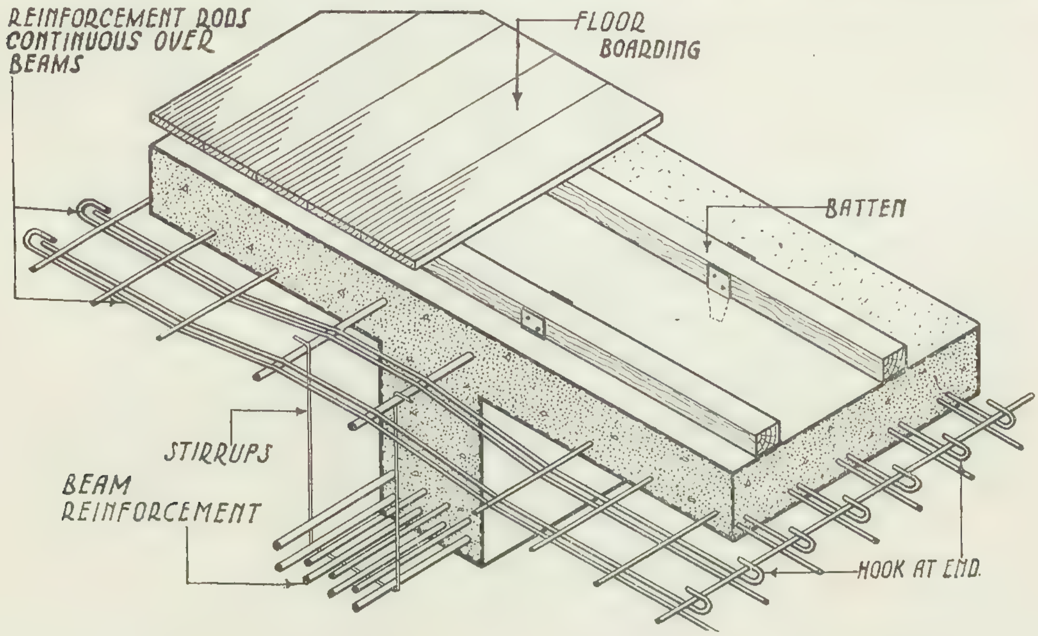

Fig. 92. Reinforced Concrete Tee Beam and Floor Slab

assist resistance against any tendency to slip. There is of course a natural adhesion between the two materials which is brought about by the frictional resistance of the steel and the setting of the concrete.

As the tensional stresses occur at the lowest part of a beam so they will occur in this position in a floor slab; therefore the reinforcement bars should be placed as near as possible to the bottom of the slab and sufficient room only be allowed for an effective covering of the steel by the concrete.

Floor slab reinforcing bars are sometimes placed in one direction only, but it is more usual to design the slabs so that the reinforcements run in two directions or at right angles to each other.

Solid floor slabs composed of reinforced concrete are more generally used in combination with reinforced concrete tee beams and reinforced concrete-framed structures. Thus the whole of the building is monolithic in structure. A sketch showing the arrangement of the reinforcement for a concrete tee beam and floor slab is given in Fig. 92. The beams should be concreted at the same time as the slabs are formed.

It is the common practice to use steel rods as the reinforcing medium. Expanded metal reinforcement may be used economically and in some instances in preference to steel rods; especially if the expanded metal is laid continuous over the supporting beams.

Cracks in Floor Surfaces. Large floor areas are subject to cracks which frequently occur immediately over the floor beams. These cracks are most noticeable in corridors, and especially where a jointless floor surface is laid directly upon the concrete floor slab.

Many preventive methods have been tried out and incorporated in the construction of the floors. Extra steel bars have been placed over the beams and embedded in the concrete of the floor slab on either side. Another method is to

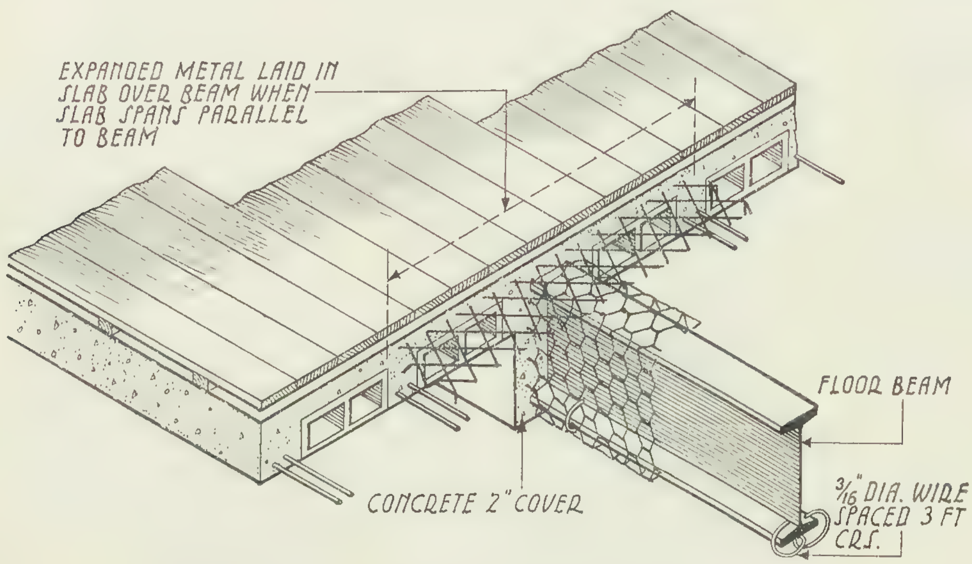

Fig. 93. Reinforcement Placed over Floor Beams

place expanded metal in the concrete and over the beam (see Fig. 93). Although this extra reinforcement will assist in preventing these cracks, it will not eliminate them. A better method is to form a groove about 2 in. wide in the concrete immediately over the floor beam; and when the erection of the building is completed and the floor finishings are ready to be placed in position, fill the grooves with bitumen.

Concrete and Filler-joist Floors. The construction of fire-proof floors with coke-breeze concrete in which small rolled-steel sections are embedded is now largely superseded by other types of floor construction.

Many reasons account for this change. The chief ones are the advancement made in reinforced concrete design, the particular function of steel when embedded in concrete, and the inadvisability of using coke breeze as an aggregate for the concrete.

The combination of brick aggregate concrete or ballast concrete and filler-joists will ensure a good structural floor, which is however heavier than the more recent types, and is less economical in the use of steel.

Hollow Block and Filler-joist Floors. An improved type of filler-joist floor may be obtained by using burnt clay hollow blocks in the place of concrete. The blocks are placed so as to rest upon or receive support from the filler-joists.

The floor finish is built up from a concrete layer which is formed over the top surface of the floor blocks. A sketch showing this type of floor is given in Fig. 94.

Ribbed Floors. Ribbed floors are formed by incorporating a system of small ribs or tee beams, which are spaced at frequent intervals throughout the floor slabs. This system has brought about many changes in recent methods of floor construction.

It has already been noted that the tensional stresses which occur in the lower

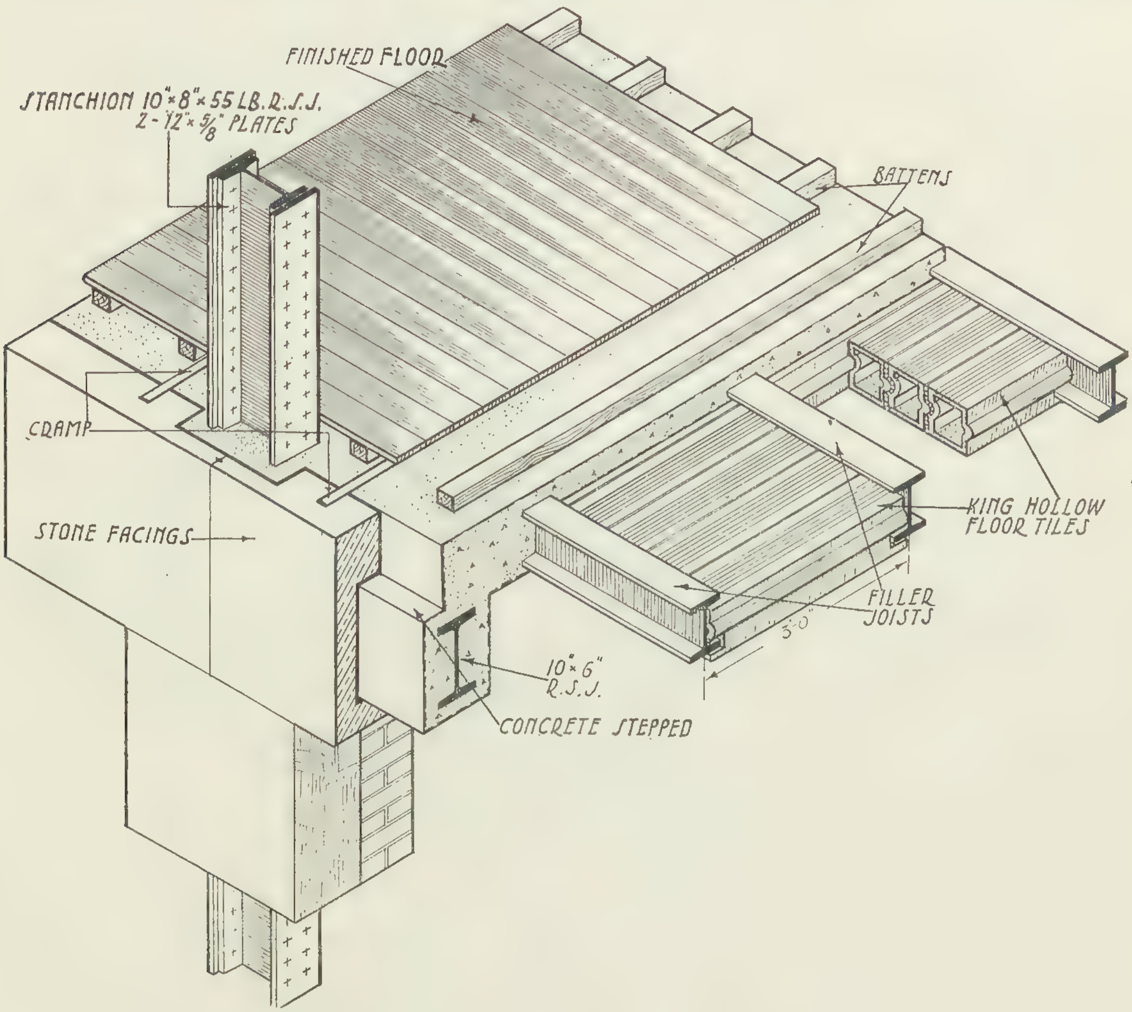

Fig. 94. "King" Hollow Block and Filler-joist Floor Construction

part of a concrete beam are resisted by the insertion of steel bars; if, therefore, instead of equally distributing the reinforcing bars over a floor slab area they are grouped in bunches about 18 in. apart, the dead load of the floor can be lessened by eliminating the unwanted concrete in the portions of the slab between the groups of reinforcement. By the removal of this superfluous material the underside of the slab will take the form of a series of ribs, each rib being reinforced with a number of steel rods which are concentrated close to the bottom of the ribs.

Hollow Block Floors. Again, the underlying principle of big-span hollow block floors is the same as reinforced concrete tee beams or ribbed floors.

The hollow blocks add very little strength to the floor, in fact they add

weight which may be undesirable; but their inclusion provides a fairly regular under surface for the ceiling of the room below.

It has been mentioned that a certain portion of a floor slab is cantilevered out on each side of the supporting beam, and the steel reinforcing bars are continuous over the beam so as to assist in resisting the stresses. If, therefore, a regular system of smaller beams, which are reinforced on the same principle as the main beams, is introduced throughout the slab, the thickness of the concrete floor slab between these smaller beams can be very considerably reduced.

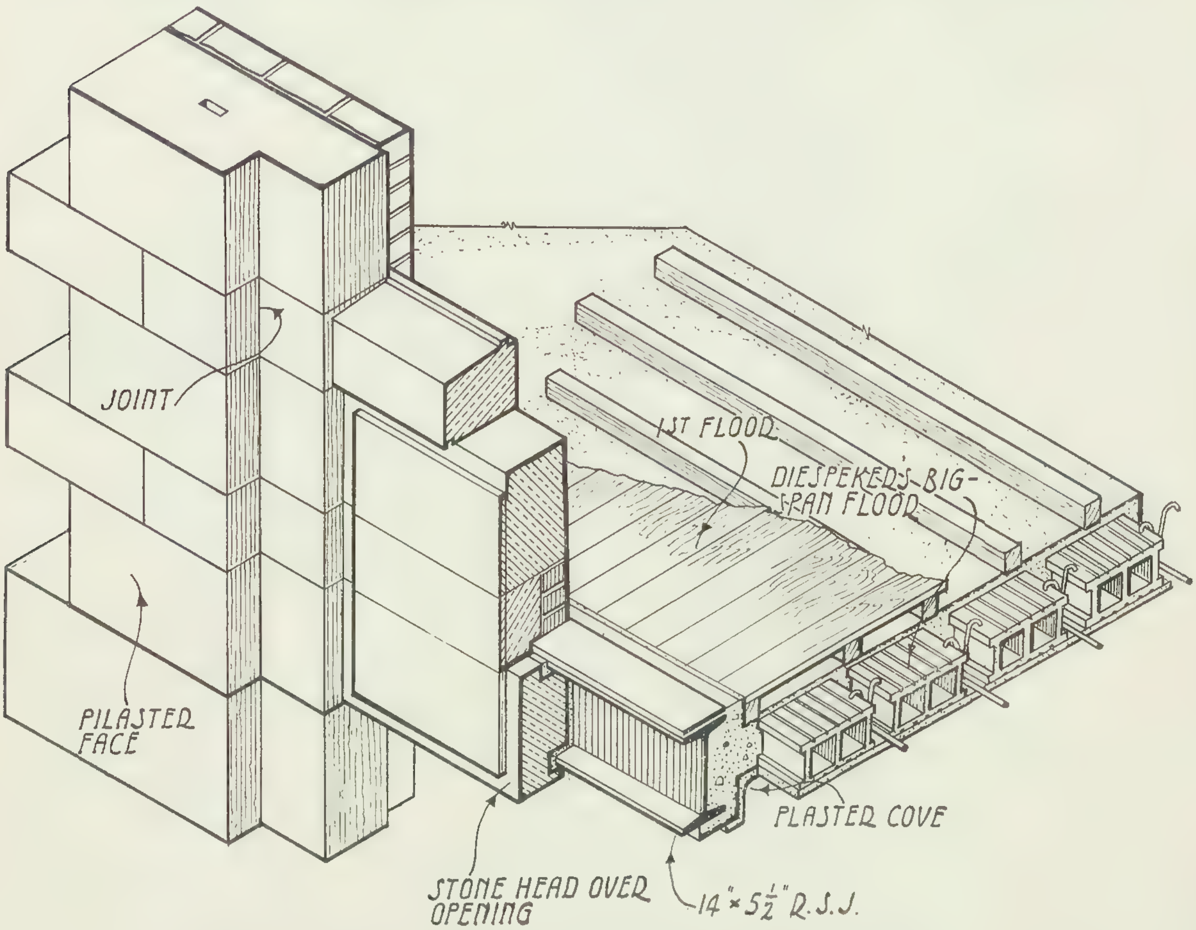

Fig. 95. Construction of "Big Span" Hollow Block Floor

These secondary beams usually run in one direction only, but they may be designed so as to run in two directions, that is at right angles to each other.

Hollow block floors have largely replaced solid concrete floors, because they are light in weight compared with solid concrete and therefore yield some economy in the erection of the formwork and wood centering.

From the foregoing remarks it will be gathered that the hollow blocks may be omitted from the construction, but the omission will necessitate the inclusion of a suspended ceiling connected to the underside of the ribs.

The most common types of hollow floor blocks are made from brick earth and in sizes about 12 in. wide, 4 in. to 6 in. deep, and 12 in. long, each block having open ends and grooved surfaces which thus form the key for the concrete and plaster ceiling. In construction the blocks are laid end to end, in the form of a hollow tube which fills the space between the reinforced concrete ribs.

Some of the well-known types of hollow block floors may be studied by means of the sketches throughout this volume. Attention is drawn to Figs. 62, 75, 95, and 96 as being typical examples. It will be noticed that the constructional principles of each of these floors are very similar, but minor differences exist and each type may rightly claim to have its own peculiar advantage.

Self-centering Floors. The high cost of centering for the support of floor slabs during their erection and setting has brought about various methods in the construction of floor slabs which will eliminate its use.

Self-centering floor slabs are formed by placing precast units side by side. These span from beam to beam, or joist to joist. Afterwards they are

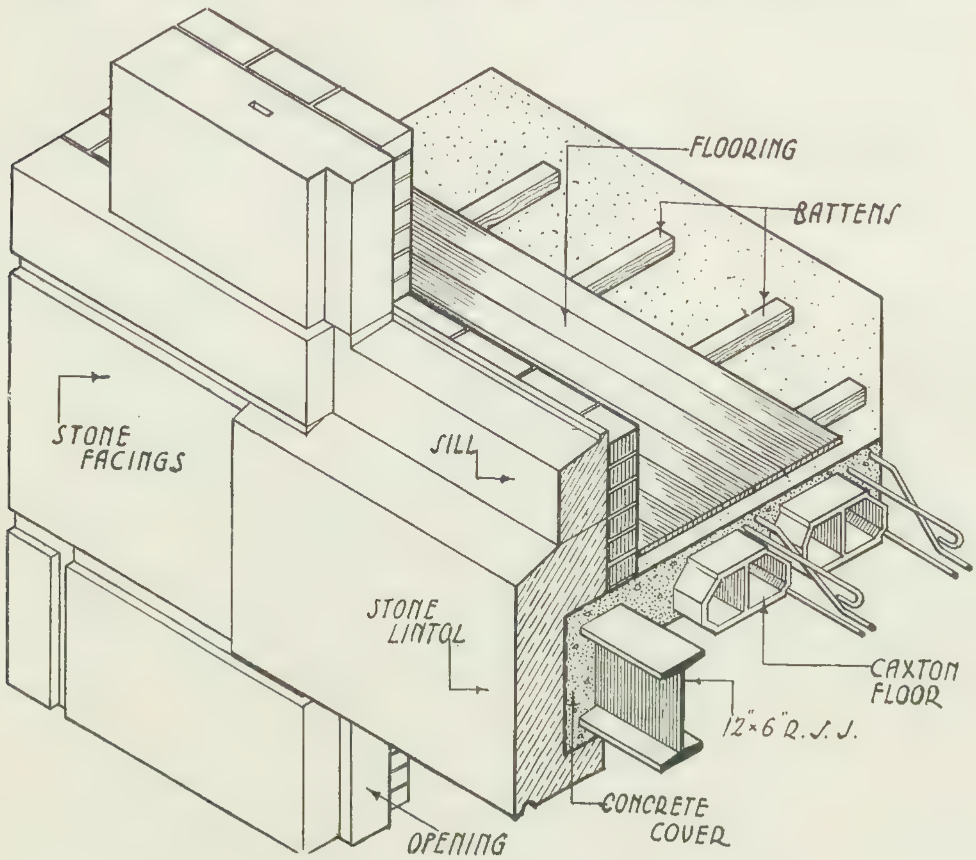

FIG. 96. CONSTRUCTION OF "CAXTON" HOLLOW BLOCK FLOOR

covered with a surface layer of concrete which forms the foundation for the floor finishings.

Some types of precast floor units require the inclusion of a suspended ceiling, but this should not be considered a disadvantage, since the requirements of modern building equipment almost demand the provision of suspended ceilings. A space between the underside of floor slabs and the finished ceiling is necessary for the housing of the ventilation ducts and service pipes, those essentials of modern heating and ventilating systems.

There are several kinds of self-centering floors, many of which are included in the constructional details throughout this volume: in particular attention may be called to Figs. 40, 72, 76, 144 (*a*), and 144 (*b*).

These types of floor construction are economical and speedy in erection—

important considerations in modern conditions—since they can be loaded soon after they are made, or used as platforms for the storage of building materials and even as working platforms during building operations.

Floor Finishings

The term "floor construction" in this book refers to the structural part of a floor, or that part of the beams and slabs which form the base for the flooring proper, and the term "floor finishings" will have reference to the surface finishings or to that part of a floor above the structural slab.

Floor finishings will vary according to the use to which the building is to be put.

Wood floor finishings are generally permitted in fire-resisting construction, and it is to this type of building that these notes have direct application.

The development of fire-resisting construction and the need for insulation of floors against heat and sound transmission have brought into use many kinds of flooring materials and various methods of building-up the floor finishings. It is not possible to lay down any hard and fast rule as to the type of floor finishings which may be used. Each type should be considered upon its own merits and according to the individual requirements of each case.

Jointless Floor Finishings. Patent jointless and composition floor finishings appear to be less used than they were at one time, preference being given to some form of tile finishing.

In jointless floors the composition is spread upon the screeded floor slab in a plastic state, after which it hardens into a durable surface. The composition is composed chiefly of calcide magnesium oxide and magnesium chloride and can be made to any colour, and skirtings may be formed in the same material and continuous with the floor.

Granolithic Floor Finishings. For some purposes, granolithic floor finishings are very suitable. They produce a very hygienic and hard floor surface, which can be easily cleaned, especially if the skirtings continue with the floor surface.

Terrazzo Floor Finishings. Terrazzo floor finishings are widely used and are most suitable where cleanliness and durability are essential. To minimize the effect of crazing, which is one of the disadvantages of terrazzo floor finishings, the present way is to make precast terrazzo tiles or squares, and to lay them as tiles rather than to form the floor surface in one piece.

Another method is to divide the floor surface into tile patterns by placing brass strips on the screeded concrete floor before the terrazzo is applied. This process is in effect the formation of a terrazzo tiled floor cast *in situ*.

Wood Block Floor Finishings. For ground floors and where heavy traffic is anticipated wood blocks are often used as a floor finishing. The screeded concrete floor is coated with a layer of pitch and tar or bitumen, and the blocks of wood are laid on this layer after being dipped in hot pitch and tar. This process tends to prevent the early decay of the wood blocks. A smooth floor surface is formed by mechanically planing the upper surface of the blocks so as to bring them to one smooth and uniform surface.

Rubber Floor Finishings. Rubber floor finishings are made by vulcanizing pure rubber under pressure and cutting it in the form of tiles. The use of an adhesive is essential in laying the rubber, the basis of which is a rubber solution.

Before laying rubber floors the upper surface of the floor slab should be screeded with a mixture of fine sand and cement; and if there is any likelihood of damp penetrating into the floor slab, the top surface of the slab should be coated with a layer of mastic asphalt before the cement screed is laid.

Cork Floor Finishings. Floor finishings composed of cork, or like material manufactured from cork shavings, are now in considerable use. They are made from $\frac{3}{8}$ in. to 2 in. thick, and compressed in tile moulds and then baked. A special paste is used as an adhesive, and the tiles are laid direct on a screeded surface.

This type of floor finishing is very resilient and gives warmth and quietness to the tread.

Because of modern methods of warming floor surfaces for the heating of buildings the insulative qualities of cork offer advantages as a floor finish.

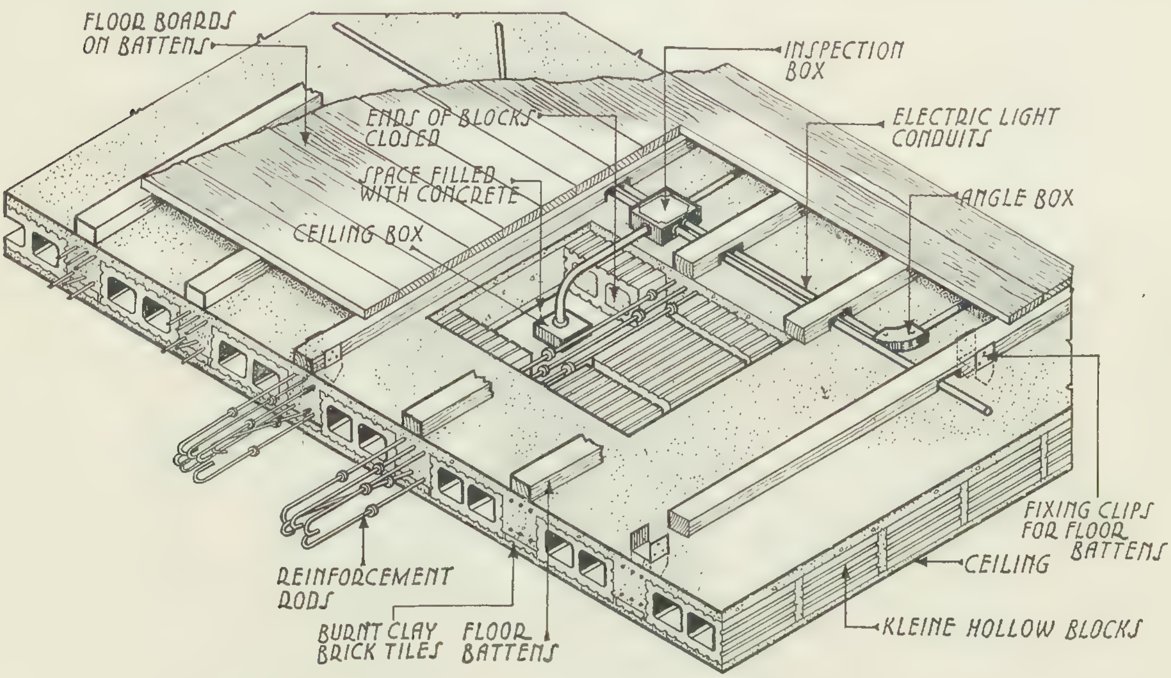

Fig. 97. Method of Housing Service Pipes under Floor Finishings

Compressed cork is also very considerably used in the building up of sound-proof floors, as will be seen in the chapter on "Sound-proofing." Fig. 50 shows a reinforced concrete floor covered with cork slabs and finished with linoleum.

Floor Boarding. Floor boards are commonly used as the floor finishing for concrete or hollow block floors.

When floor boards are required to form the floor finishings in these cases, it is necessary to secure the boards to the concrete. This may be done by laying them direct on to the cement screed, or by fastening them to wood battens or joists which are situated immediately under the boards. If the boards are laid direct on to the cement screed they should be bedded in a mixture of pitch and tar, or some other bituminous material, when nailing is not required.

A better method is to secure the boards to wood battens, thus allowing an air space between the underside of the floor boards and the top surface of the floor slab, as shown in the various sketches throughout this book. The spaces between the battens are sometimes filled in with fine cement or light-weight

concrete, but this method is not to be recommended. The spaces should be left vacant for the free circulation of air to the surfaces of the timber; also they are very convenient for the housing of the various pipe systems, as shown in Fig. 97.

A number of patent clips have been specially designed for securing the wood battens to the concrete floor in preference to nailing. One particular type of clip is shown in Fig. 97.

If a more resilient and sound-resisting floor is desired, this may be obtained

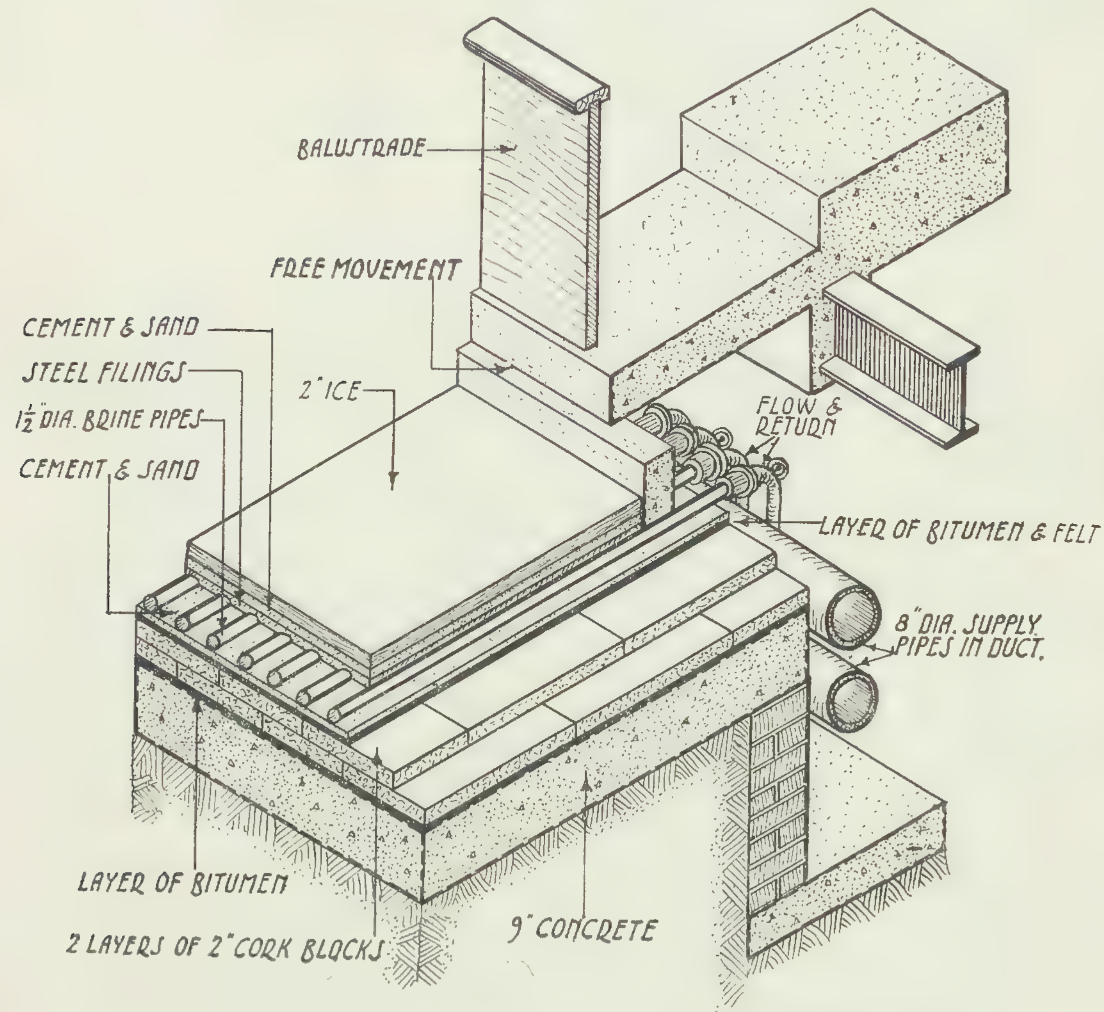

Fig. 98. Construction of Ice Floor showing Arrangement of Brine Pipes

by embedding "Fibrecrete" fixing blocks in the concrete of the floor-slab and surmounting the structural slab with a system of counter battens as in Fig. 76. These battens are fastened to the structural slab and form the base for the support and fixing of the floor boards.

Construction of Ice Floors

The construction of ice floors has received special attention during recent years and their development has been a gradual evolution from the highly polished terrazzo floor finish to the artificially formed ice finish. The developed use of refrigerating plant has been very largely responsible for progress in the use of the ice rink floor.

The principle of the construction of these floors is the covering of the floor area with a system of brine pipes. The low temperature to which brine can be reduced before freezing point is reached allows for a free circulation of brine through the pipes at a temperature sufficiently low to freeze the water when it is applied to the upper surface of the floor. For this action to be effective, the pipes must be embedded in the floor and the lower part of the floor insulated. Various methods have been adopted to meet these requirements and some have proved successful.

One of the recent methods of construction is as follows. The whole of the floor area is first covered with a layer of hard-core and then with a 9 in. slab of plain or reinforced concrete. If the condition of the site demands further precautionary measures against damp, a system of surface drainage should be formed and a surface layer of concrete covered with mastic asphalt formed over the site. This is done before the reinforced concrete floor proper is placed in position.

A layer of mastic asphalt should be spread on the top surface of the reinforced concrete floor slab, then a built-up insulating course comprising two layers of 2 in. cork blocks or slabs. These layers should be covered with a layer of bitumen and felt, and screeded with a layer of cement and sand. Brine pipes of $1\frac{1}{2}$ in. diameter are laid on this screeded surface and steel filings are packed tightly between the rows of pipes. Another screeded layer of cement and sand is afterwards placed on the top of the steel filings, and forms the base for the ice covering.

It is important that the top screed of cement and sand shall be laid perfectly level throughout the whole of the floor area, otherwise an unequal thickness of the ice will result.

The floor being reduced in temperature, through the medium of the brine flowing in the pipes, causes the water to freeze when it is sprayed on the floor surface. This process of spraying is continued until the ice has attained a required thickness of 2 inches.

A sketch showing the construction of an ice floor and the arrangement of the brine pipes is given in Fig. 98.

CHAPTER VI

ROOF CONSTRUCTION AND ROOF COVERINGS

Roof Construction. All roofs require to be constructed so that the roof surface will have a certain inclination to the horizontal in order to shed the rain-water.

There are two chief classes of roofs—

(1) Flat roofs. (2) Pitched roofs.

Flat roofs will have only a slight inclination, or a sufficient amount of "fall" to allow the rain-water to flow to outlets; whilst the surfaces of pitched roofs will vary in inclination from an almost flat to one of extreme pitch.

The angle of pitch is often governed by the type of covering material, but the architectural design and construction of a building will have an important bearing upon the type of roof covering and the construction of the roof. The framework of a roof will be referred to in these notes as "the roof." The materials, both impervious and structural, will be referred to as "the roof covering."

Roof construction has changed through the greater variety of roofing and building materials obtainable in these days. Whereas roofs were once constructed of timber, or timber and cast iron, they are now being made with steel and reinforced concrete, and covered with either one or more of these modern materials.

Just as floors are required to be covered with a series of finishing layers, so modern roofs are required to be covered with layers which will provide a lasting insulated, fireproof and waterproof covering; that is, one which will protect the building and its occupants from heat and cold.

The Roof Truss. The development of the roof truss has been brought about by the need to cover large spans or large areas without intermediate support, and to prevent an outward thrust being exerted on the walls due to roof loads.

A roof truss is a framed structure; and since a triangle is the only geometrical figure which cannot change its shape unless one of its sides is lengthened or distorted, a roof truss is made up of a number of triangles framed together.

Roof trusses are of great variety. They used to be made of timber; now they are usually made of steel. The type of truss to be selected for a given instance is determined by the length of span and the type of roof covering.

In modern building construction, roof trusses are used only where it is desired to cover large areas without intermediate support.

The king post, queen post and the Mansard roof trusses are all relics of timber roof construction.

When roof trusses are desired in modern construction they are usually made of steel, but owing to the preference often given to some form of flat roof, steel roof trusses are often dispensed with.

Trussed or latticed girders are used in order to bridge the span and transfer the loads to the end supports. When rooms were desired to be constructed within the roof area it was usual to incorporate a Mansard roof, because this type of roof has two distinct surface slopes; the lower one, being almost vertical, allows for the provision of extra floor space within the roof area.

Construction of Deck Roofs. When constructing roofs in conjunction

with steel-framed and reinforced concrete-framed structures, the framed roof truss is not now necessary.

When extra floor space is desired within the roof area, the modern method of construction is to continue the steel framework up to the desired height, and to form a steeply pitched roof in concrete or hollow blocks and surmount it with a flat roof. This type is known as a *deck roof.*

The modern tendency is to take advantage of this method of construction and to incorporate a system of multiple floors within the roof area.

Usually the pitch of the roof surface of each floor level will be determined by the requirements of the local by-laws which regulate the height of buildings.

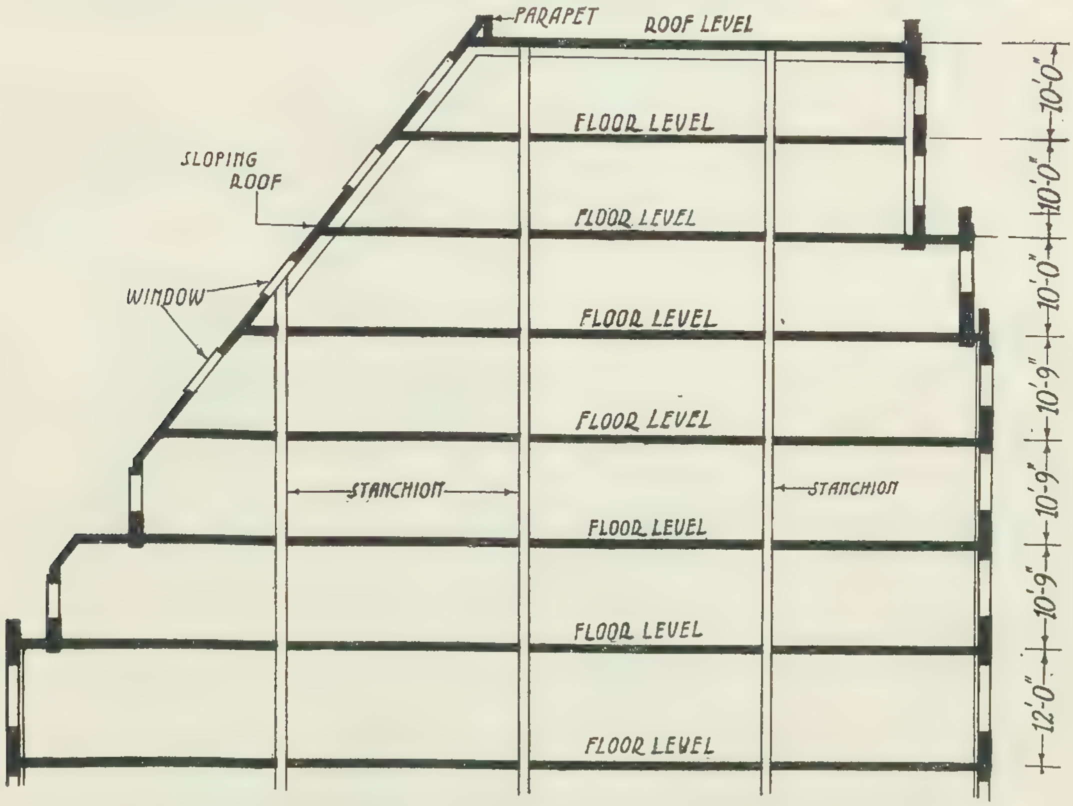

FIG. 99. SECTION THROUGH A DECK ROOF CONTAINING SEVERAL FLOORS

A diagrammatic section illustrating the outline of a roof containing multiple floors within its area is given in Fig. 99. It will be noticed that when a roof is constructed on these lines and in combination with a steel-framed structure, framed roofs as such are not necessary.

This book does not claim to deal with the main forms of roofs used in building construction, but only to give examples of those roofs which are popular in modern practice.

Construction of Flat Roofs. The flat roof is often believed to be the distinguishing feature of modern building.

This is not so, but it may be said that the flat roof has come into prominence in modern building as a result of the attention given to fire-resisting materials.

Flat roofs are not new features. For many years they have been constructed in timber and covered with sheet lead or copper. They have always given a

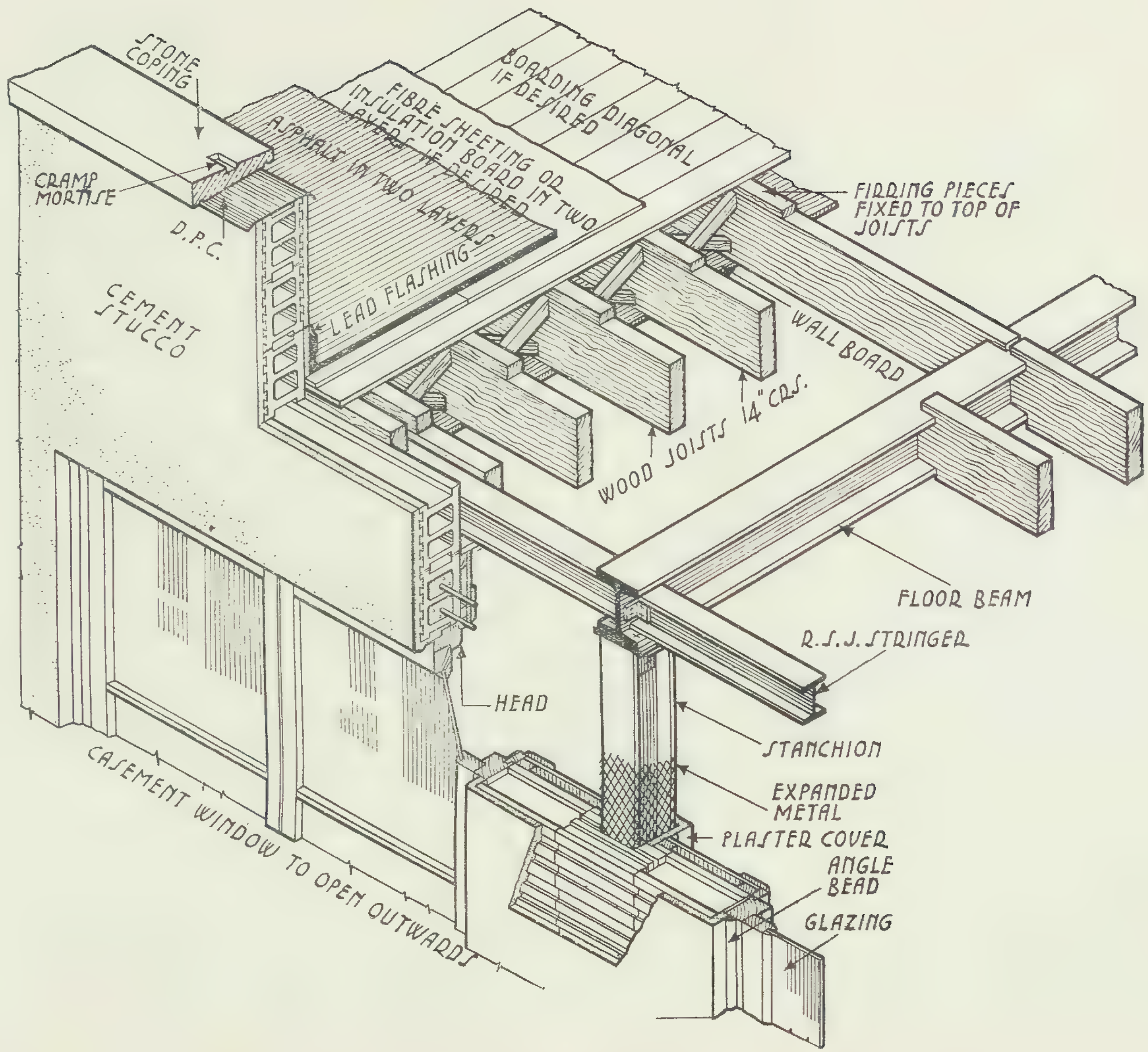

Fig. 100. Construction of Timber Flat Roof

certain amount of trouble through the difficulty of keeping them waterproof over a lengthy period.

There is no reason why such roofs should fail to function properly, but their success will depend upon the method of construction and the type of covering material used. Flat roofs are now constructed chiefly in some form of fire-resisting material, and on the same lines as floors. The dimensions of the beams and slabs and the method of reinforcing are calculated as for floors, because most flat roofs are used as promenades, etc., and are subjected to live loads as are floors.

When reinforced concrete and hollow blocks are used in roof construction, the slabs are usually covered over or screeded with a layer of cement and sand and laid to a fall so as to discharge the rain-water to the various outlets. This screed is then covered with one of the many forms of roofing materials, such as mastic asphalt or bituminous sheeting.

The covering of flat roofs with bituminous sheeting is often considered to be a cheap and temporary method, thus depreciating the value of a building. But the manufacture and application of these materials have so improved that a very excellent and lasting roof covering may be formed by using them.

They should be applied in layers or plies, with bituminous layers between. Each sheet may be reinforced with fabric or some form of membrane reinforcement, and many of these sheets have qualities which make them very suitable for roof coverings. Fig. 100 shows a flat roof constructed in timber and covered with mastic asphalt.

Whilst the construction shown in this example is intended for a semi-permanent type of building, there is no reason why it should not be incorporated in a more permanent structure. A more fire-resisting roof could be formed with very little extra cost by building up the slab with precast concrete beams as shown in Fig. 72. These beams are cast in lengths to span from joist to joist, and their ends are shaped to fit into the webs of the joists and to rest upon the bottom flanges. They can be cast solid as shown in the sketch, or as hollow tubes as shown in Fig. 140.

After the slab units have been placed in position they are covered with a layer of cement and sand, which in turn is covered with two layers of mastic asphalt.

The construction of a usual form of hollow block flat roof may be seen in Fig. 101.

The covering should be formed in two layers of asphalt and the screed above the hollow blocks laid to a "fall."

Fig. 102 shows what is perhaps a better form of construction. The floor slab is covered with three layers of bituminous felt, then a 2 in. layer of concrete is placed directly upon the top layer of felt.

The roof surface is formed by bedding precast concrete tiles upon the concrete layer. This method ensures a permanent type of roof especially if the flashing at the junction with the parapet walls is arranged as in Fig. 89.

The finish for a flat roof which projects beyond the face of a wall is always a difficult problem. Fig. 84 illustrates how this may be carried out. The concrete roof slab extends beyond the face of the wall and forms the bottom member of a cornice. A gutter is formed above the cornice and covered with asphalt.

The construction of a flat roof which terminates over an external wall and

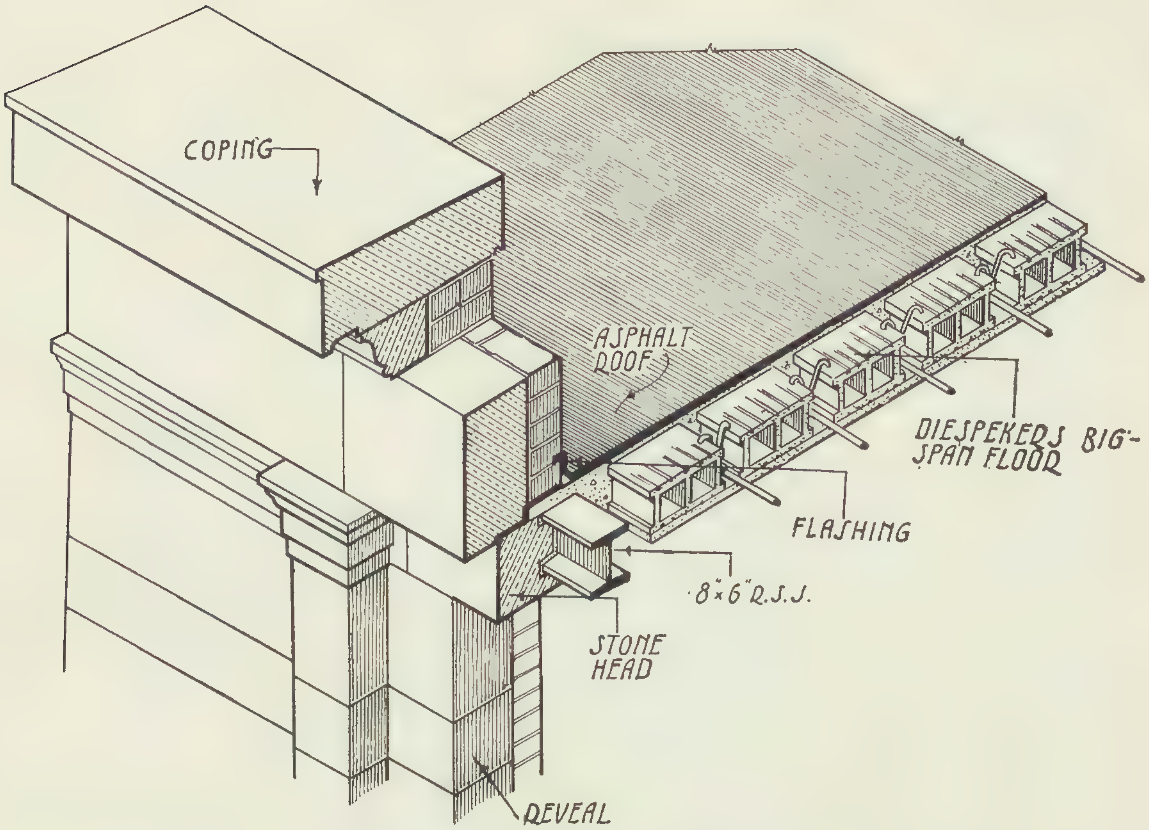

FIG. 101. CONSTRUCTION OF FLAT ROOF WITH HOLLOW BLOCKS AND COVERED WITH MASTIC ASPHALT

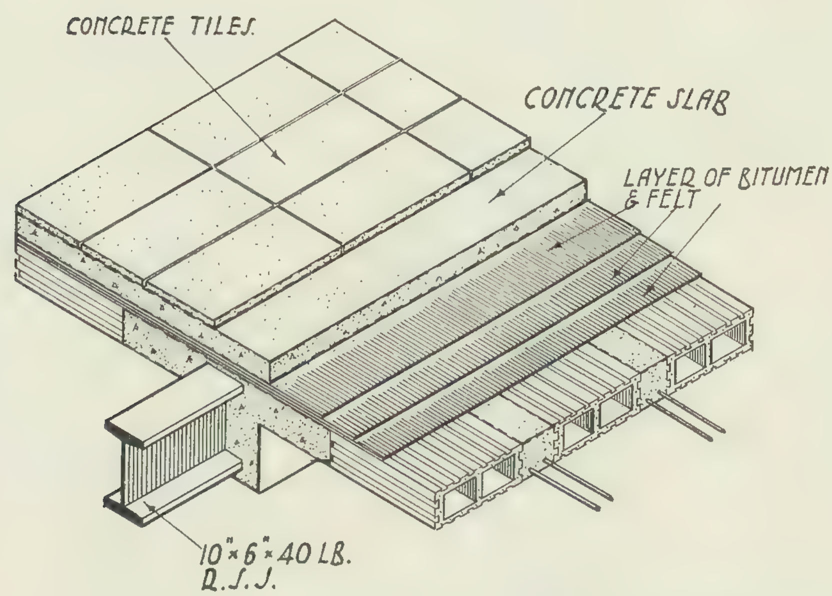

FIG. 102. CONSTRUCTION OF FLAT ROOF SHOWING ARRANGEMENT OF INSULATING LAYERS

is intended to discharge the rain-water into a cast iron gutter is shown in Fig. 103.

Construction of Pitched Roofs. Pitched roofs may be constructed in timber or reinforced concrete or hollow blocks. When they are constructed in timber they should be covered with slates or tiles fastened to wood battens. Fig. 85 shows the construction of a timber pitched roof. The rafters are covered with felt sheeting and then battened. The roof surface is finished with slates which are head-nailed to the battens. The felt sheeting is used instead of close boarding.

The sketch also shows the construction of the eaves for such a roof, and includes details for covering over the cavity in a $11\frac{1}{4}$ in. cavity wall. The inclusion

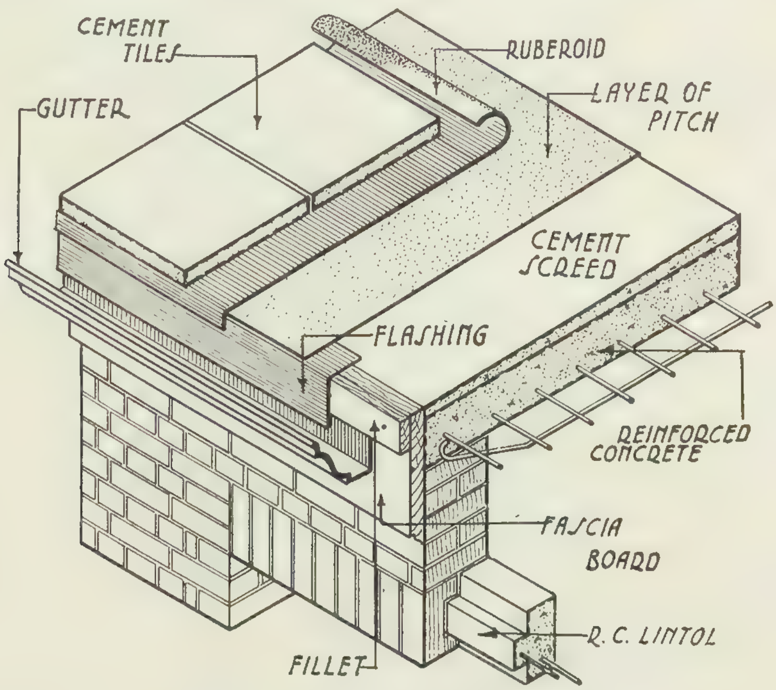

Fig. 103. Construction of Flat Roof
Showing arrangement for discharging the rain-water into a cast iron gutter.

of sheeting or felts under the slates or tiles will improve the insulating qualities of a roof; but the timber is liable to early decay if air is excluded from its surfaces.

It is common practice for timber roofs to be close-boarded, then covered with roofing felt; after which the wood battens are spaced to suit the size and type of roof covering. Care, however, should be taken to allow for the free circulation of air.

The procedure often adopted when a pitched roof is constructed in reinforced concrete or hollow blocks may be seen in Fig. 104. In this instance the sloping surface is covered with Westmorland slates fastened to a system of counter-battens which are laid vertically and horizontally. The spaces between the vertical battens are filled with fine concrete. The pitched portion of the roof terminates above the flat or deck roof, so as to form a parapet to enclose the flat portion of the roof and to give the appearance of extra height. Also the roof springs from the top of the wall and a cast iron gutter rests upon the top course of stone. Thus the crowning member of the wall is formed without recourse to an eaves.

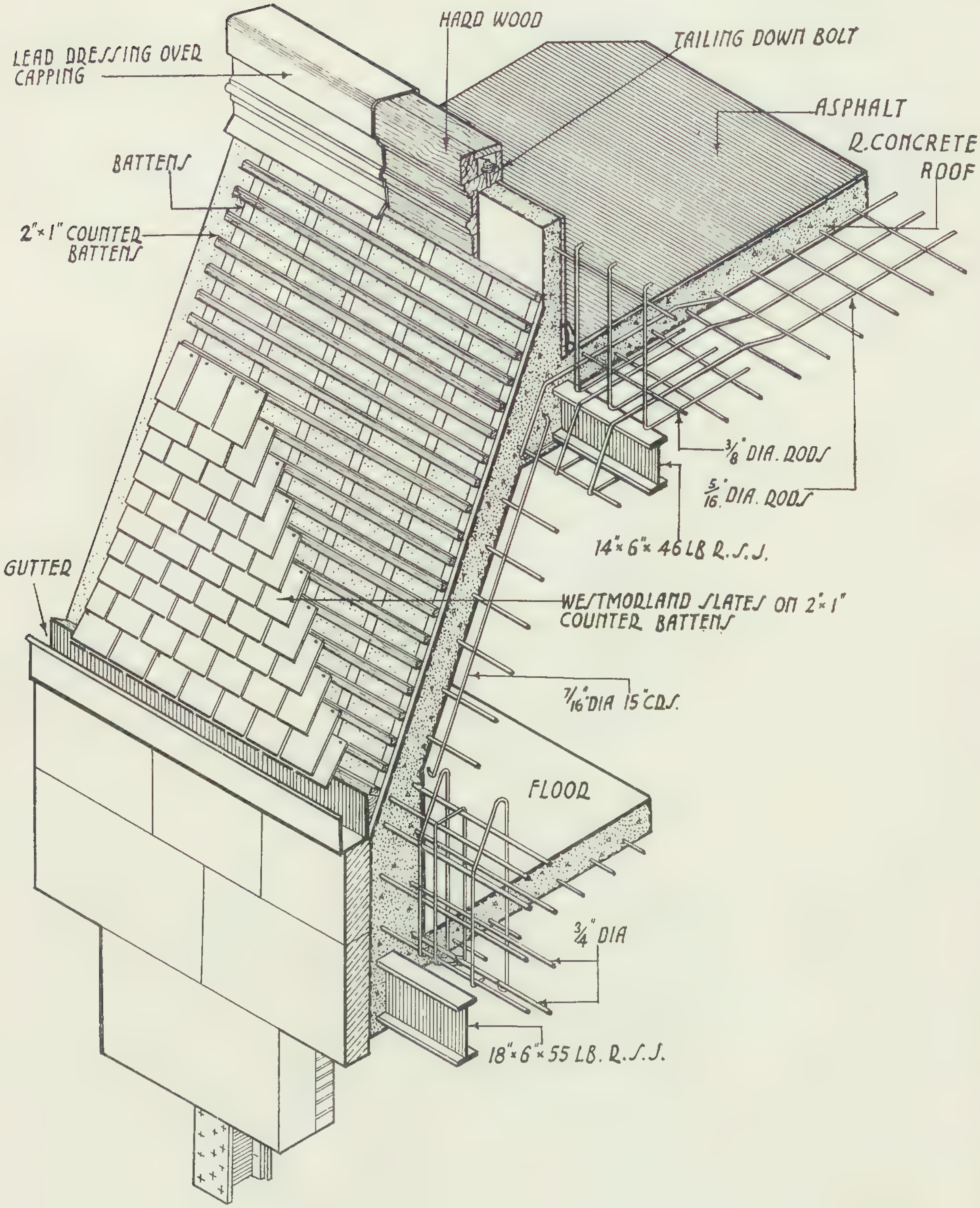

Fig. 104. Construction of Reinforced Concrete "Deck" Roof showing Roof Finishings

Eaves. There are many varieties of eaves design. Although one of the chief functions of an eaves is to close the junction between the wall surface and the roof rafters, an eaves is a means for keeping the rain-water clear of the wall of a building. It is generally formed in connexion with a timber roof, and then the ends of the rafters may be boxed-up as shown in Fig. 85.

In steel- and concrete-framed structures an eaves is usually dispensed with, and the base or springing of the roof commences from a parapet gutter. It should be designed so that the rain-water from the roof surface will discharge into a metal gutter fixed on the top of the wall as shown in the sketch. Again the top surface of a cornice may be given the form of a gutter covered with sheet lead or asphalt.

In modern architecture, and especially when a flat roof forms part of a reinforced concrete structure, an eaves is often made to be a continuation of the reinforced concrete slab and designed as a covering or cantilevered roof over a balcony.

Its chief difficulty lies in the method of finishing off the covering, and is most prominent when the roof is to be covered with mastic asphalt. If the construction of the covering is carried out as shown in Fig. 84, there will be no difficulty in obtaining an efficient roof.

Fig. 86 shows how a flat roof slab may be covered with a timber pitched roof.

The sketch shows the construction of an eaves when the concrete roof slab projects beyond the face of the wall and forms the soffit of the eaves.

Lantern Lights. Lantern lights are usually associated with flat and deck roofs, whereas roof lights are associated with pitched roofs.

Lantern lights are constructed in the same manner as roofs; that is, they are formed as lean-to and pitched roofs with hipped or gable ends.

In the construction of large lantern lights it is usual to include small trusses like roof trusses as part of the framework.

Lantern lights are employed to illuminate auditoriums, rooms, staircases, etc. Formerly they were made of timber; now they are usually formed of metal and reinforced concrete.

Their construction is very simple when they form part of a reinforced concrete or hollow block roof. Very little framing is necessary as they are usually supported on a reinforced concrete curb or on steel joists, placed so as to form a base for the curb. A sketch showing such a concrete curb is given in Fig. 105, together with details of a metal frame lantern light. There are many types of metal frames but they are all somewhat similar in make; therefore the one shown may be taken as a typical example.

The chief advance seems to have been made in the design of the glazing bars which will secure the glass without the use of putty. Details of glazing and sash bars are given in Figs. 106 (*a*), 106 (*b*), 106 (*c*), and 106 (*d*). They should be kept to the smallest dimensions so as to allow a maximum effective glass area.

When constructing lantern lights provision must be made for the trapping and discharge of condensation moisture which will form on the inside surface of the glass. Grooves and channels should be provided, and these connected to the exterior of the building by means of weep-pipes as shown in the sketch.

Only reinforced or armour-plate glass should be used as glazing for lantern or roof lights.

The lower part of the roofing sheets must not be fitted tight against the vertical glazing or framework. A space between them ought to be allowed so that the condensation moisture will discharge clear of the internal vertical surfaces.

Draughts may be prevented by incorporating a lead wind-guard as shown in Fig. 106 (*a*).

Indirect Lighting. The importance attributed to the beneficial effects of

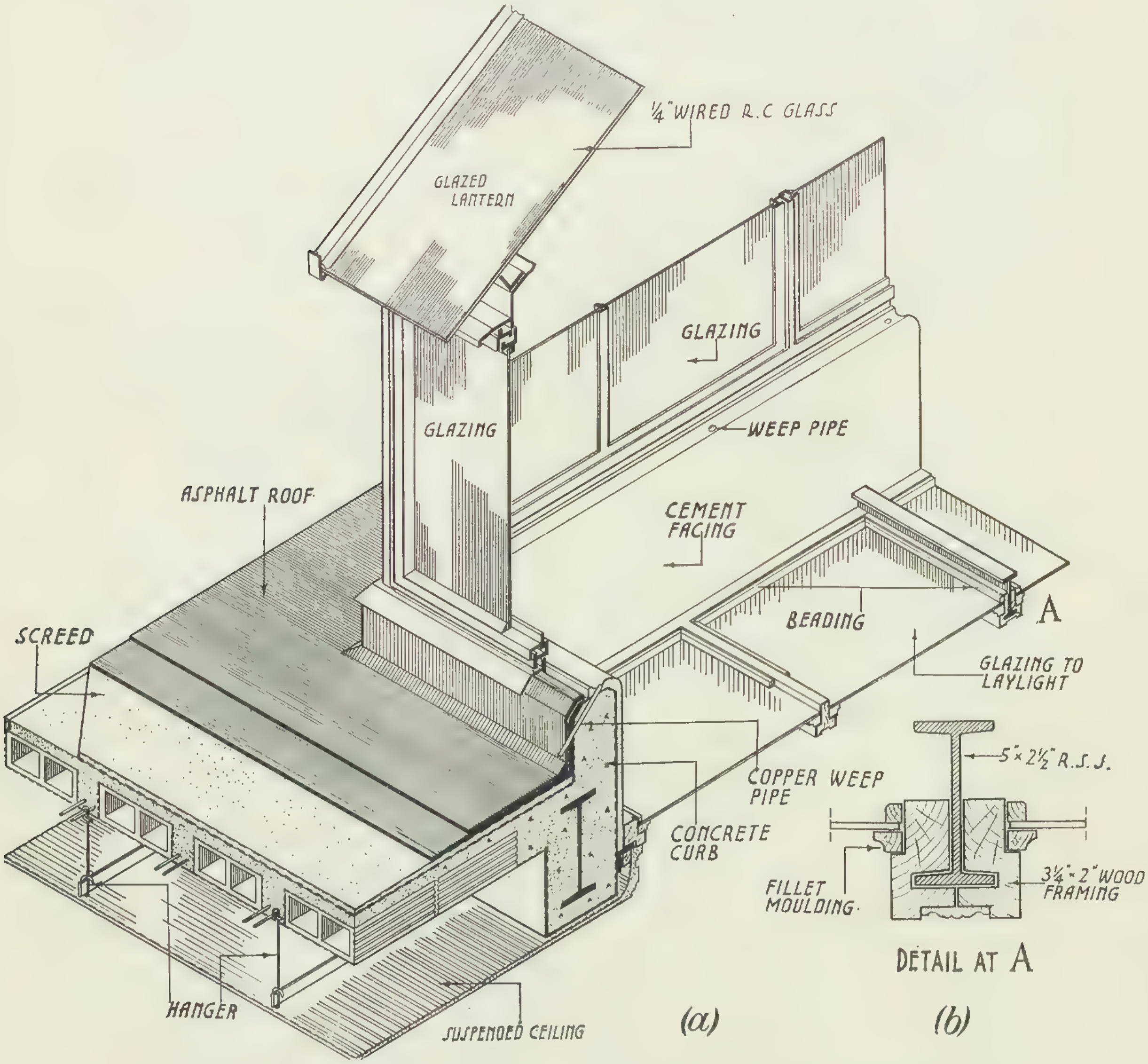

FIG. 105. DETAILS SHOWING CONSTRUCTION OF METAL FRAME LANTERN LIGHT

(*a*) Detail of curb and lantern light. (*b*) Detail of laylight and framing.

various light rays upon the health of the occupants of buildings has contributed towards the inclusion of special glazing for the windows of buildings. Also the advance that has been made in the methods of the lighting of buildings has resulted in the recognition that diffused lighting is more beneficial to the occupants than direct lighting. Hence various forms of indirect lighting devices have been introduced. The provision of suspended plaster ceilings has assisted the development of diffused lighting. The lighting units may be placed in the ceiling and form part of the decorative treatment.

Fig. 107 shows a bent glass lighting trough connected to the framing of a suspended plaster ceiling. The glass trough rests upon special metal angle sections and can be easily removed when desired.

The development of glass rods and tubes as electrical lighting units has largely assisted in creating the various forms of ceiling and panel lighting. A tubular lamp of 40 mm. diameter is shown in the sketch. These glass tubes are blown

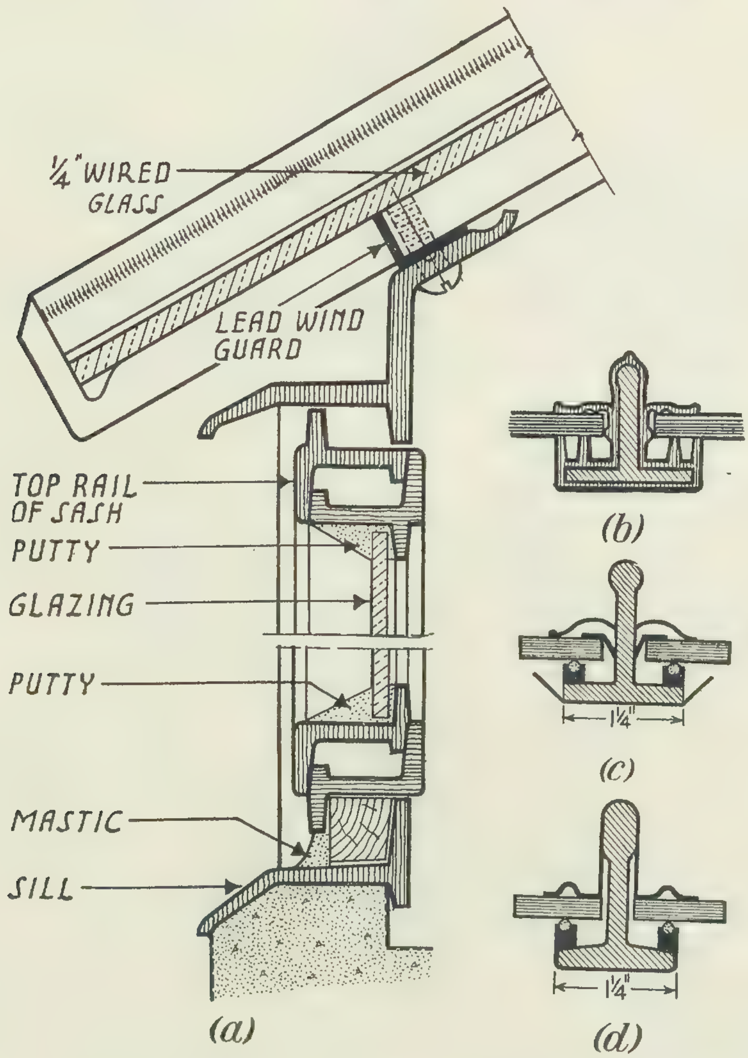

Fig. 106. Details of Metal Sash and Glazing Bars

(a) Section through metal sash.
(b) Detail of glazing bar.
(c) Detail of glazing bar.
(d) Detail of glazing bar.

from a solid mass, and although a cylindrical section is shown, almost any desired section can be obtained. The tubes may be made in clear glass or they may be tinted to any colour to give the desired effect.

Laylights. Laylights are used as a means for effecting indirect lighting and are commonly associated with lantern lights. This association is not an essential one. They may be a part of a suspended ceiling and in this way the occupants of a room can enjoy artificial sunlight during the winter months and be freed from external weather conditions. These boons can be attained by means of an artificial lighting system put above the laylights and glazed with chosen

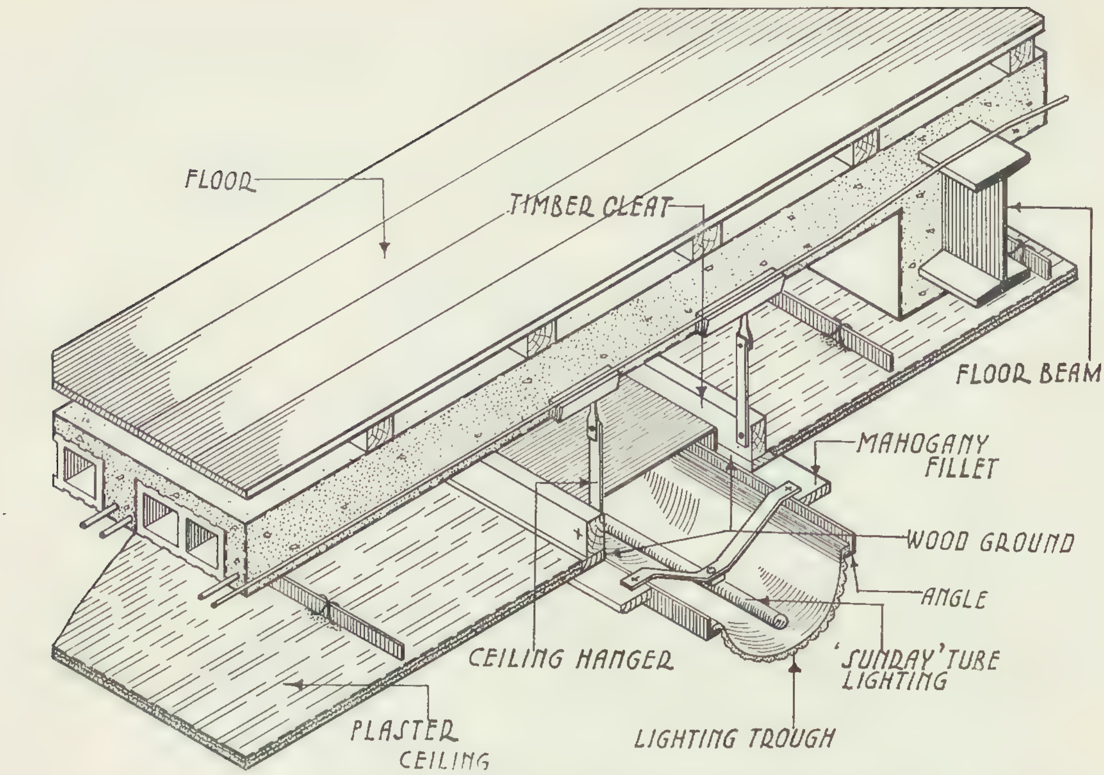

FIG. 107. DETAIL THROUGH BENT GLASS TROUGH CEILING LIGHT

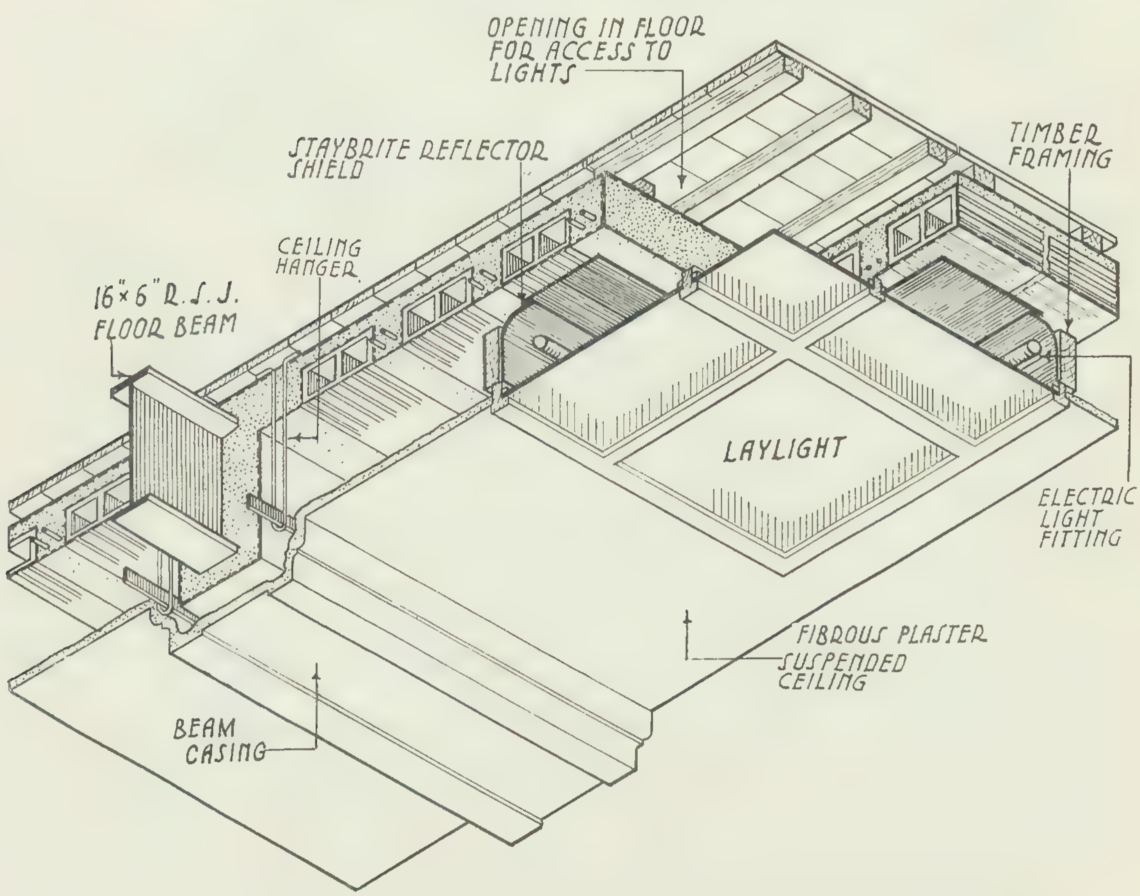

FIG. 108. CONSTRUCTION OF LAYLIGHT AS PART OF A SUSPENDED CEILING

colours as in Fig. 108. In this example the laylight is formed as part of a suspended ceiling and situated under a hollow block floor.

In circumstances such as this, provision must be made for access to the lighting fitments. This means of access may be made through the floor of the room above and immediately over the laylight, as shown in the sketch, or by providing hinged sashes in the laylight framing. Laylights are constructed in the form of glazed horizontal panels. The frames are of wood or metal and the bars

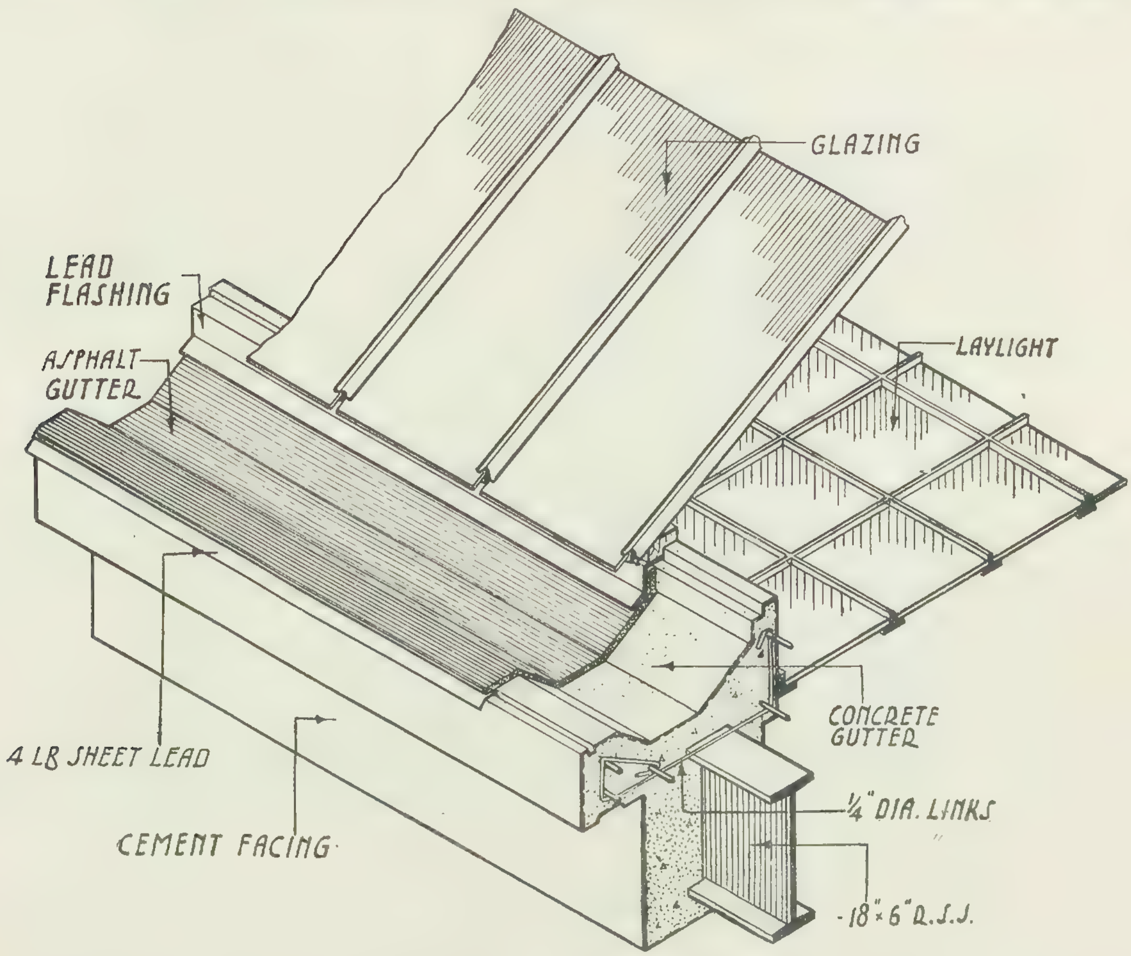

FIG. 109. CONSTRUCTION OF METAL FRAME LAYLIGHT UNDER A GLAZED ROOF LIGHT

rebated to form a seating for the glass sheets. A sketch of the construction of a timber frame laylight in combination with a lantern light is shown in Figs. 105 (*a*) and 105 (*b*).

Fig. 109 illustrates the construction of a metal frame laylight under a roof light.

Roof Coverings

The framework of a roof must be covered with a material which will provide a lasting and fire-resisting covering. The covering should also insulate the framework of the roof and the surrounding constructional materials from wide temperature changes.

Whatever is used for the waterproof roof covering, an insulating material ought to be placed under or over the waterproof material (according to circumstances) so

as to prevent the transmission of the sun's heat, which is usually absorbed by waterproof materials.

Types of roofing materials differ widely in character, appearance, durability, weight, fire-resistance, and suitability.

Roofs may be covered with thatch, stone, concrete slabs, corrugated iron sheets, glass, wood shingles, slates, tiles, sheet lead, sheet copper, sheet zinc, mastic asphalt, felt, asbestos sheets and tiles, and bituminous felt.

Slates and tiles are the most suitable materials for covering pitched roofs. They are heavy but enduring and lend dignity to the design of the building.

Although lead and copper sheets are very good materials for covering flat roofs of moderate size, mastic asphalt and built-up bitumastic roofing materials have taken their place very largely in flat roof construction.

Fire-resisting structures may be roofed with a combination of some of the materials already mentioned; or they may be treated in an entirely different manner. A reinforced concrete roof may incorporate glass discs which can be arranged in geometrical patterns and act as a means for lighting the interior of a building. The concrete used in this type of roof should be waterproofed by adding one of the many waterproofing compounds when mixing, and afterwards by painting its exposed surface with a bituminous paint.

Built-up Roof Coverings. This type of roof covering is suitable for flat roofs.

It is made up in a series of layers or plies which can be laid either on timber framing or on concrete and hollow block slabs. When laid on timber the framework should be close boarded, and then the roof covering made up in alternate layers of bituminous felts or of felt and mastic asphalt.

Mastic Asphalt. Natural mastic combines three kinds of asphalt—

(1) Bitumen obtained from a natural deposit.

(2) Bitumen in a naturally impregnated rock.

(3) As a flux which is derived from asphaltic petroleum.

The last is used to soften the natural deposit which is too hard for use in the form in which it is imported. Coal tar pitch should not be confused with bitumen and asphalt.

The use of mastic asphalt for roof coverings is very general, and if the quality of the asphalt is up to the approved standard and the roof construction is suitable for its application, there is no reason why the material should fail to function in a proper manner.

Very much will depend upon the condition of the base upon which the asphalt is laid and whether provision has been made to allow the asphalt to expand and contract without decreasing its effectiveness as a roof covering. Flashings in mastic asphalt should be constructed so as to allow free movement without allowing water to enter the building.

The practice of constructing flashings continuous with the roofing material as in Fig. 101 often leads to failure. This is due to cracks which are caused by the expansion and contraction of the roofing material. Figs. 56 (*a*) and 89 illustrate the best method to adopt when forming the flashing for an asphalt-covered roof.

The modern tendency is to cover asphalt roofs with cement tiles, or precast concrete slabs. These coverings will insulate the asphalt and keep the roofing surface at a normal temperature. In some instances asphalted roofs are covered

with ballast. Figs. 79 and 102 illustrate the construction of a reinforced concrete roof covered with asphalt which in turn is covered with concrete tiles. The tiles or slabs are bedded in cement mortar or in a mastic compound. It is advisable to allow a width of ½ in. to 1 in. for the joints between the precast slabs and to point the joints with a mastic compound. The sketches also show the construction of a parapet gutter covered with asphalt and the finishing at the edge of the flat roof. Fig. 103 is a sketch showing built-up coverings for a flat roof.

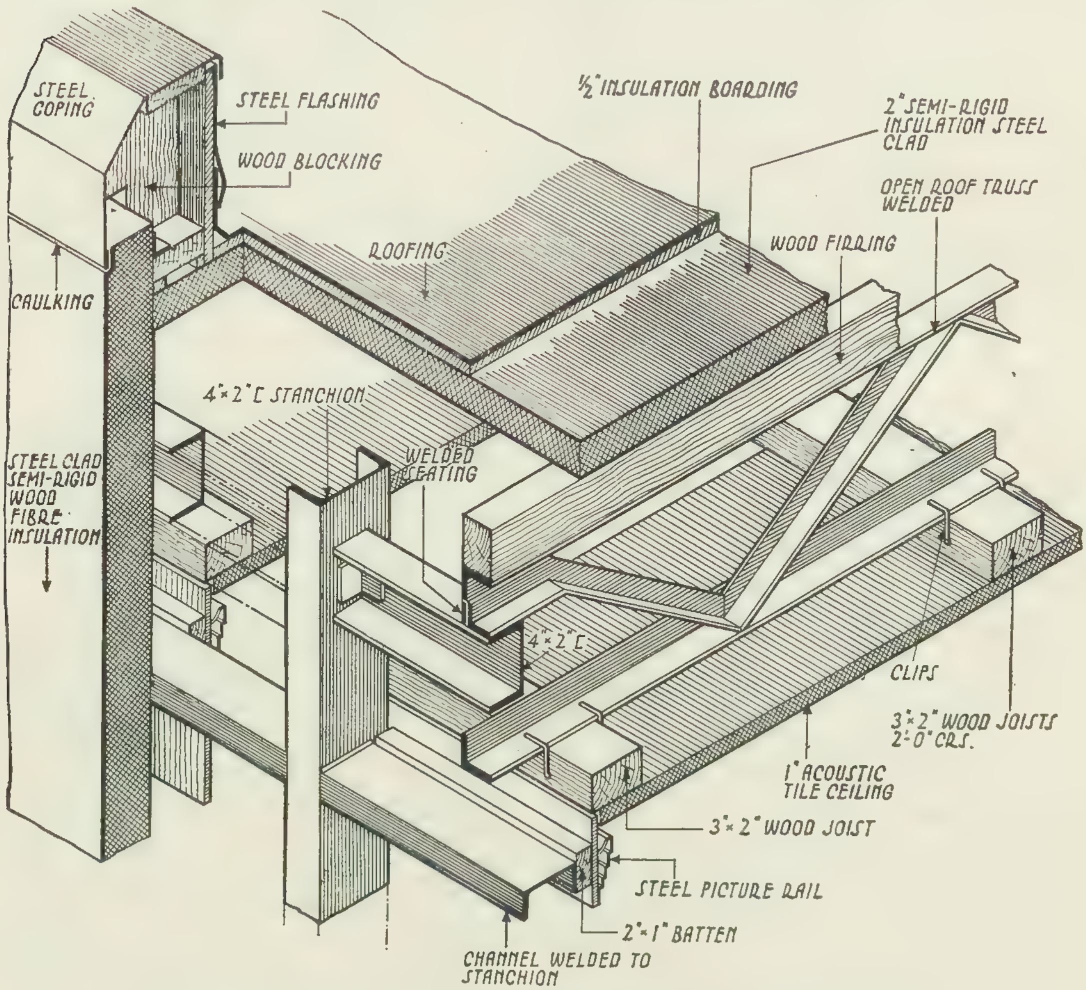

Fig. 110. Construction of Flat Roof showing Built-up Coverings and Steel Flashing

The roof slab is formed with reinforced concrete and the roof finishing is made up in layers. The impervious layer is shown covered with concrete tiles.

The construction of a new type of flat roof for a semi-permanent building is shown in Fig. 110. The roof is part of a light welded steel-framed structure. The roofing is supported on very light welded lattice girders, upon which are laid firring pieces which give the required fall for the roof surface. Upon the firring pieces are placed semi-rigid insulated steel-clad sheets; upon them ½ in. insulated boarding and then the roofing material, which can be either mastic asphalt in two layers, or one of the many bitumastic roofing materials which are used for built-up roofing.

The ceiling surface is formed with pressed fibre boards fastened to suspended ceiling joists, or joists which are attached to the underside of the lattice girders.

The construction of the flat roof in Fig. 102 shows how the sequence of the various layers of material changes the type of roofing. In this instance the bituminous felts are placed upon the concrete slab and below a concrete layer which forms a good base for fixing concrete tiles or slabs.

There are several kinds of patent roofing slabs on the market and many of these may be used successfully for covering and insulating flat roofs. These slabs are an important feature in the construction of flat roofs and especially in those intended for promenades, etc.

CHAPTER VII

CONSTRUCTION OF PARTITION WALLS

Wood Stud Partition Walls. The type of partition wall which has been in use for generations is the wood stud partition wall.

This partition wall consists of a 4 in. × 2 in. sole piece fastened to the floor boards or to the top edge of the timber joists. A head piece of similar section is fastened to the underside of the floor joists of the floor above, and between these are placed 2 in. × 4 in. vertical members or studs spaced about 16 in. apart.

Openings in studded partition walls are formed by framing the studs and using thicker members where they occur at the sides of openings.

The studs are nailed to or trenched into the sole-piece and head-piece, thus forming the framework upon which the covering material which forms the wall surface is attached.

It was the usual practice to nail wood laths to the stud framing and finish the wall surfaces by covering the laths with a coat of plaster about $\frac{3}{8}$ in. thick.

Although wood stud partition walls are still used, the form of covering has changed. A more solid and sound-resisting partition wall may be formed by filling the spaces between the studs with brickwork and short horizontal timber struts as in Fig. 111. This type of partition wall is known as a *brick-nogged* partition wall.

Framed and Braced Partition Walls. When wood stud partition walls were to be constructed parallel with the floor joist and the floor span was wide with no means of intermediate support from below, it was usual to form a framed and trussed timber partition wall as a structural member to support the loads both of the wall and floor. The timbers were framed in a manner which would resist any tendency to sag by introducing diagonal braces and connecting the head- and sole-pieces.

Iron tension rods placed vertically were also used to connect the sole-piece to the head-piece.

Modern building materials have brought about many changes in methods of constructing partition walls. Trussed partitions were designed to support the weight of the floor above or below, but they are now obsolete, because small rolled-steel sections can be used to span from wall to wall and carry the loads.

Fire-resisting Partition Walls. Steel- and concrete-framed structures and buildings of a fire-resisting character should incorporate concrete or hollow block floors in their construction, and these floors should be designed to carry the superimposed loads of the partition walls.

This is one of the many advantages of modern building methods. Commercial buildings require large floor areas which may be readily divided into small compartments by means of partition walls placed to suit the requirements of prospective tenants. Under these circumstances partition walls should be as light as possible, removable and sound-resisting. (The last matter is dealt with in the section on "sound-proofing" in Chapter IX.)

In the construction of modern partition walls use is made of such materials as wood, steel, glass, compressed fibre boards, plywood, burnt clay, hollow

blocks, breeze, plaster slabs, pumice slabs, asbestos sheets and light aggregate concrete placed between precast plaster sheets.

As stated above, wood-stud partitions may still be used in modern construction and they are very suitable in many instances; but the system of covering the wood studs has changed. In place of the lath and plaster finishing, it is usual to apply one of the many kinds of compressed fibre boarding. Where the

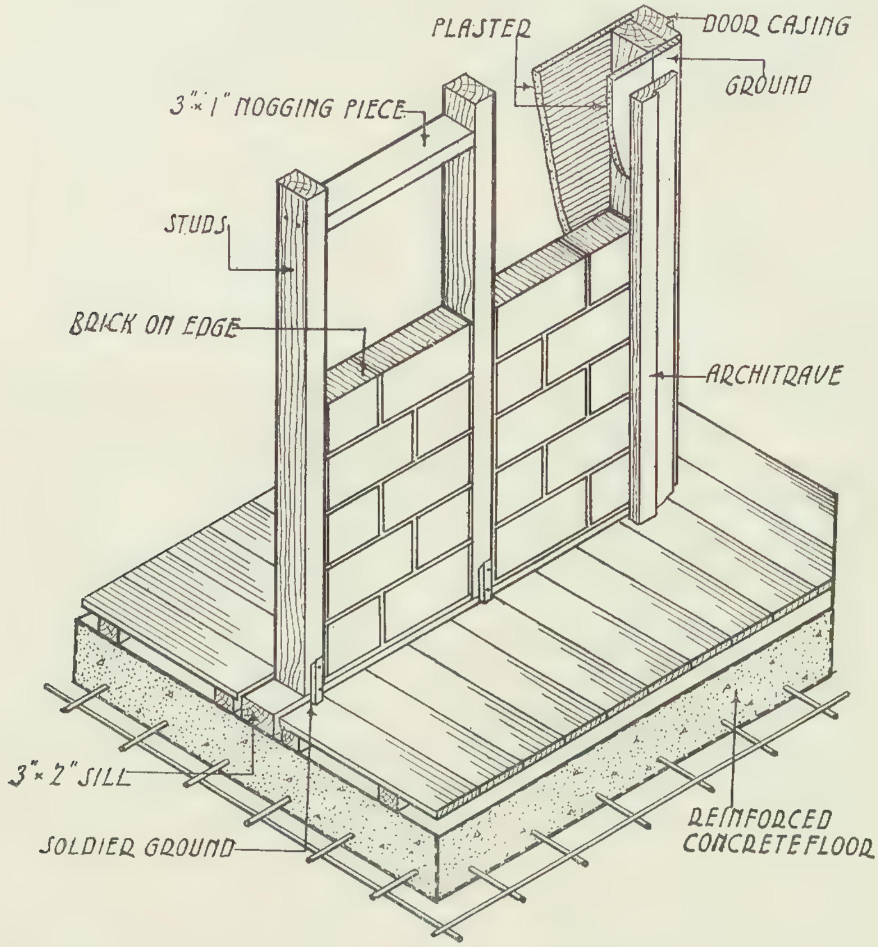

FIG. 111. BRICK-NOGGED PARTITION WALL

surface coverings are insulated, this type of partition wall may claim to have many advantages over other forms. The construction of a wood-stud partition wall incorporating insulating felt is shown in Fig. 90.

Brick Partition Walls. $4\frac{1}{2}$ in. brick partition walls are sometimes preferred, and in some circumstances their use is to be recommended. For ordinary partition walls their weight does not justify their use.

They may be plastered to form a finished surface or battened and then covered with one of the many wall sheetings.

Fig. 112 shows a 9 in. partition wall built with bricks placed on edge. This type of wall is very effective but occupies much room. It is most suitable where there is no likelihood of periodic removal. It may also be used where a special feature is to be made of a doorway opening in the partition wall and when a deeply recessed doorway is desired, as the width of the wall will lend a solid and recessed appearance to the door jamb. The wall surfaces may be plastered or

battened and boarded as shown in the sketch, which also shows the arrangement of the trim at the door jamb.

Hollow Block Partition Walls. Hollow blocks similar to those used in hollow block floor construction are used for the construction of partition walls, but the individual blocks are usually of different sizes. They are made from special clay or earth, to which is added sawdust or other such material which,

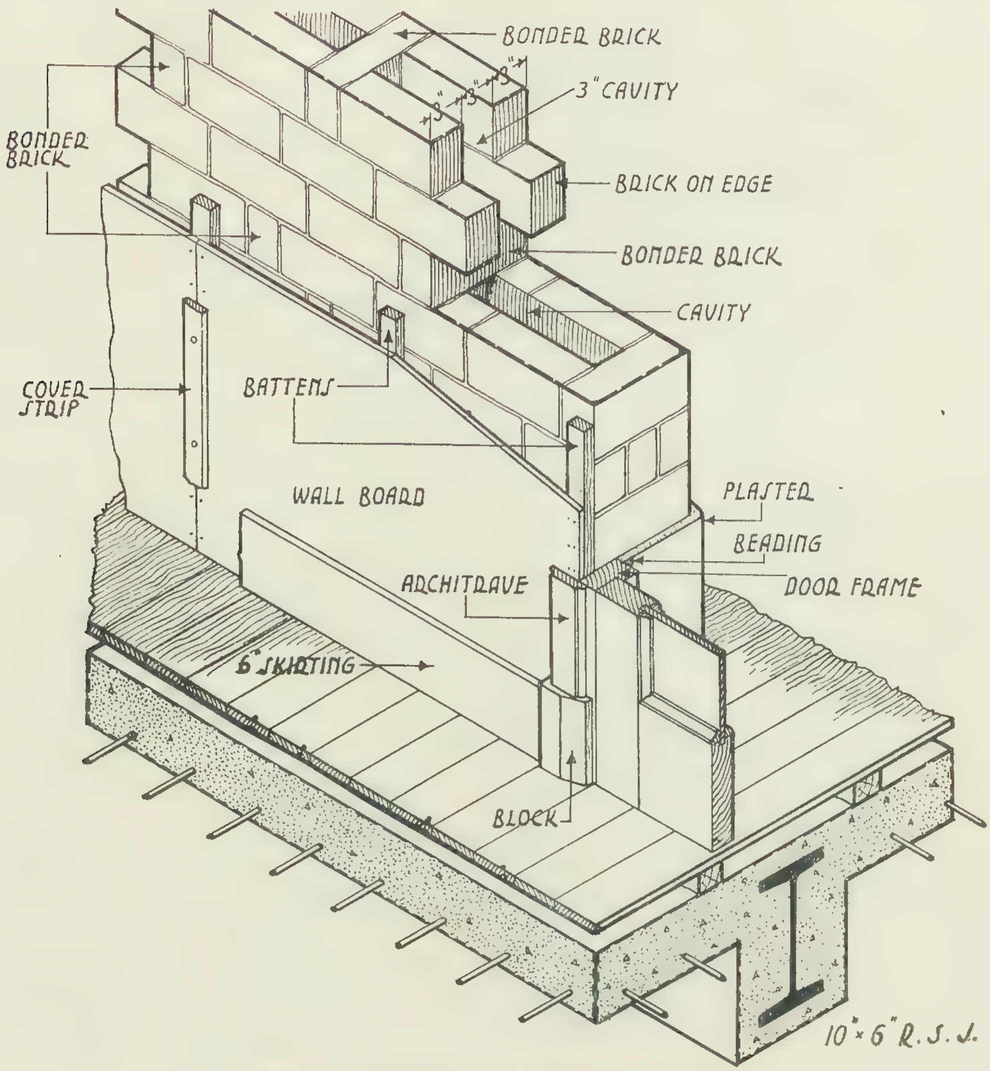

FIG. 112. BRICK CAVITY PARTITION WALL

after being burnt, produces a very light and fireproof block. Some of these blocks can be readily sawn with a hand-saw, and owing to their porous texture will permit nails to be driven direct into the material of the block. Dovetailed grooves are formed in the surfaces of the blocks to provide a good key for the plaster wall finish if desired.

Fig. 113 shows a hollow block partition wall supported upon a hollow block upper floor. It illustrates as well the construction at the jamb of a door opening, including the necessary trim.

A detail of a similar type of partition wall is given in Fig. 114. Here the sketch shows how the construction can be arranged when a partition wall

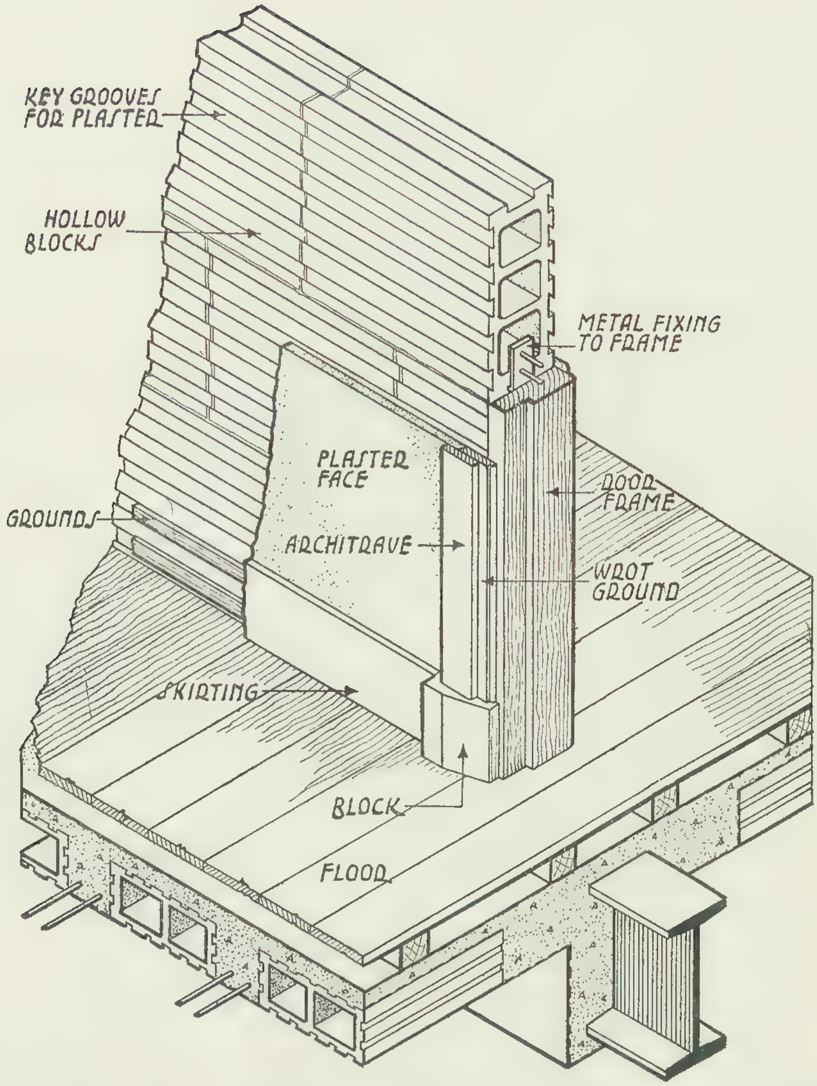

FIG. 113. HOLLOW BLOCK PARTITION WALL AND FINISH AT JAMB OF A DOOR OPENING

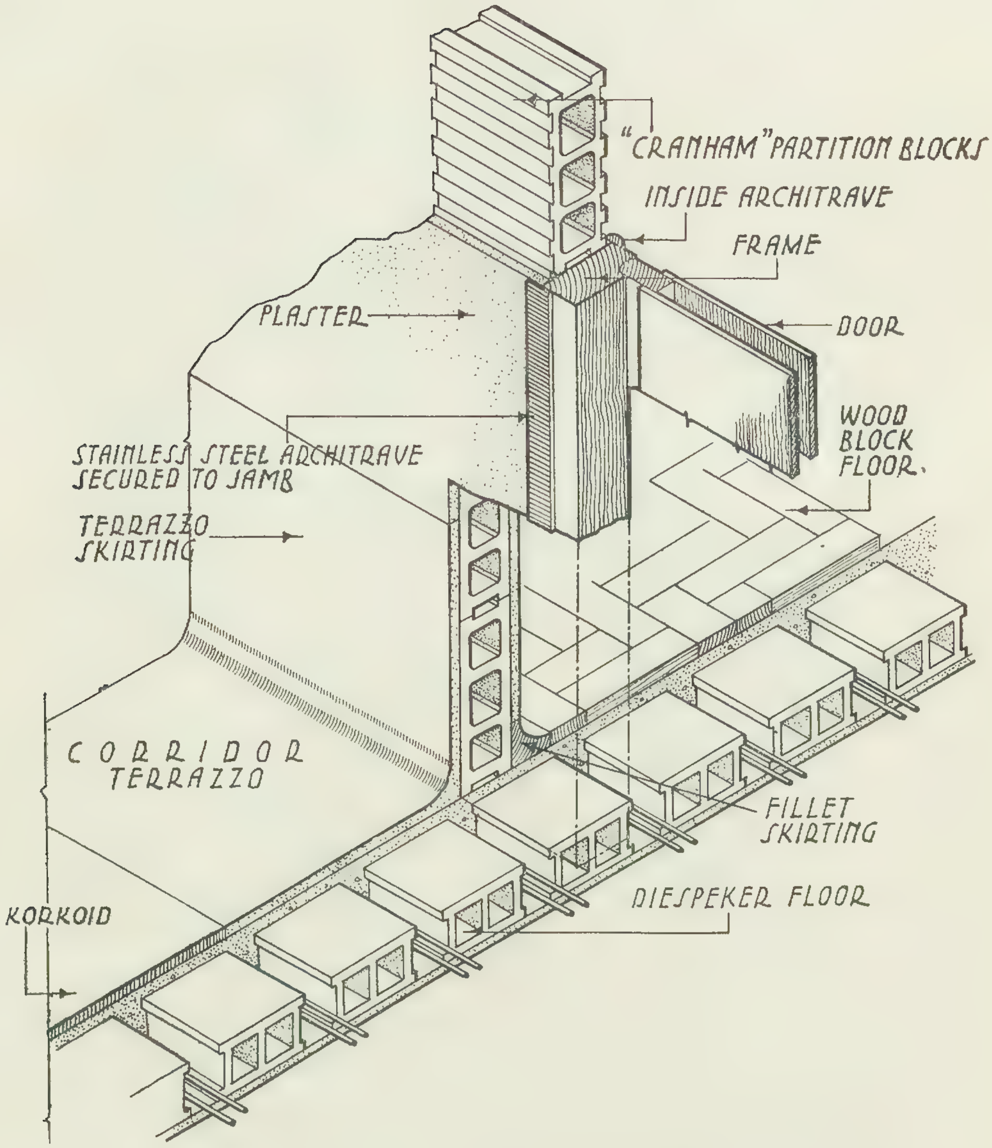

FIG. 114. CONSTRUCTION OF HOLLOW BLOCK PARTITION WALL

separates a corridor from a room. The floor surface of the corridor is formed in terrazzo and is made continuous with the skirting, whilst the floor of the room is finished with wood blocks.

Although metal trim has been discussed earlier in the book it may be noted here that a stainless steel band is introduced as the architrave member around

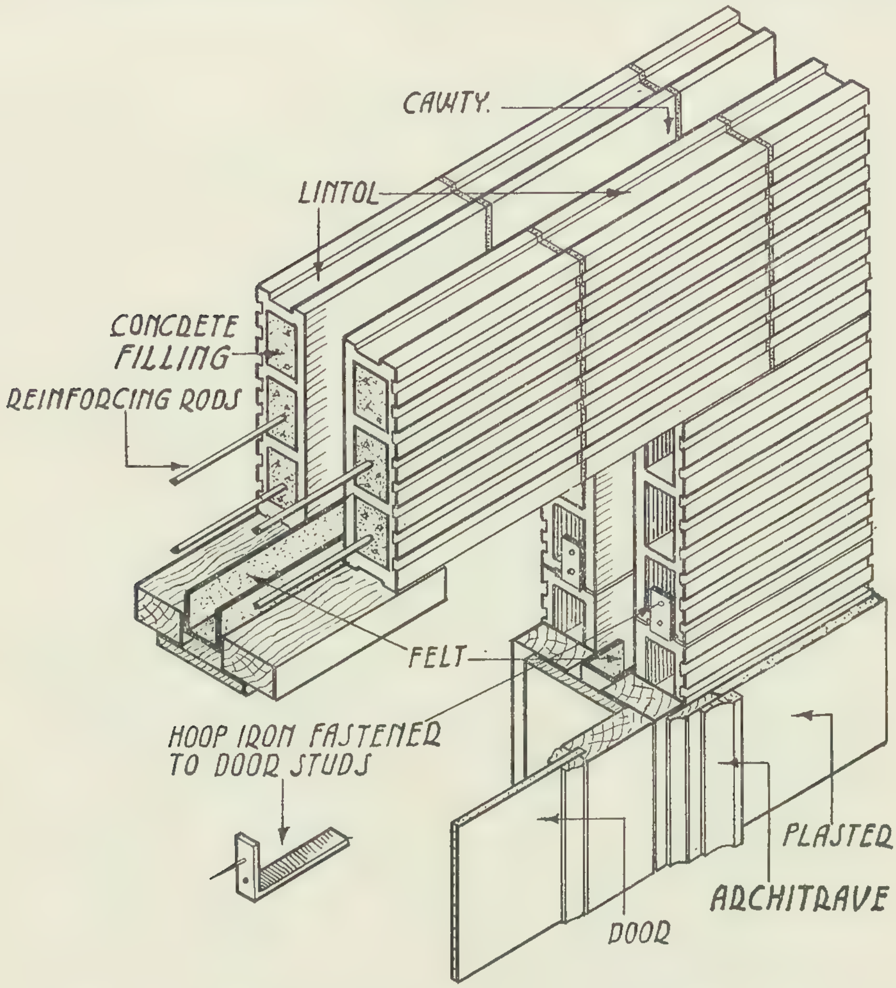

Fig. 115. Construction of Cavity Hollow Block Partition Wall
Showing method of sound-proofing.

the opening and produces a very pleasing effect when used in combination with a flush door.

Cavity Partition Walls. Hollow block partition walls are sometimes built as cavity walls; that is, a cavity is formed between two hollow block partition walls. The walls are placed in the same manner as when an external cavity wall is constructed.

The cavity may be bridged at intervals throughout the wall area by introducing some form of tie which will assist in resisting accidental shocks. As one of the chief functions of a cavity partition wall is to prevent sound-transmission through the wall, the provision of such ties should be carefully restricted, and they should be made from insulative material.

The method of covering the top of an opening in a cavity partition wall is shown in Fig. 115. The blocks which are to form the lintol are placed end to end,

before being placed in position in the wall, and the voids in the blocks are filled with fine cement concrete, and at the same time reinforced with steel rods, as in the sketch. When the concrete has set they are lifted into position as one unit just like a precast lintol.

The top rail or head of the door frame is shown covering the cavity between the two lintols. It is advisable, as will be noticed, to introduce a layer of felt in the cavity surrounding the door frame. The insertion of the felt in the position

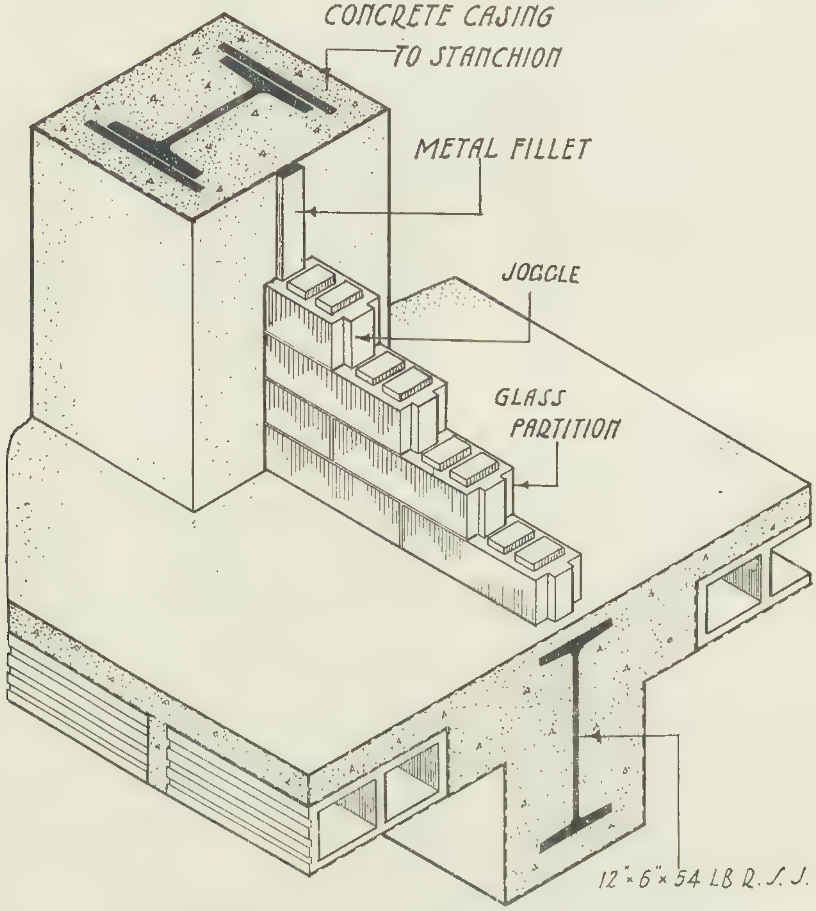

FIG. 116. CONSTRUCTION OF GLASS BRICK PARTITION WALL

shown will assist the sound-proof qualities of the partition. This will be discussed later.

Metal Core Partition Walls. Expanded metal or a special kind of metal sheeting is often used in the construction of partition walls in preference to timber, slabs, or blocks.

The metal is used as the core, and is embedded in the thickness of the wall, which is rendered rigid by metal bracings and plaster finish on either side. The metal should stretch from floor to ceiling, and be connected to these by means of small angle sections. If sound-proofing is desired it is advisable to attach the metal sheeting to both sides of a timber framework that should be first covered with an insulating material.

Glass Brick Partition Walls. It is to be expected that, with the extended use of glass for various functions in building construction, attention will be given to the production of glass units for partition walls.

Wood and metal partitions with glazed panels have been in use for some years, but unless they are equipped with double panes of glass they are not sufficiently sound-resisting.

There are various types of glass units which may be used for the construction

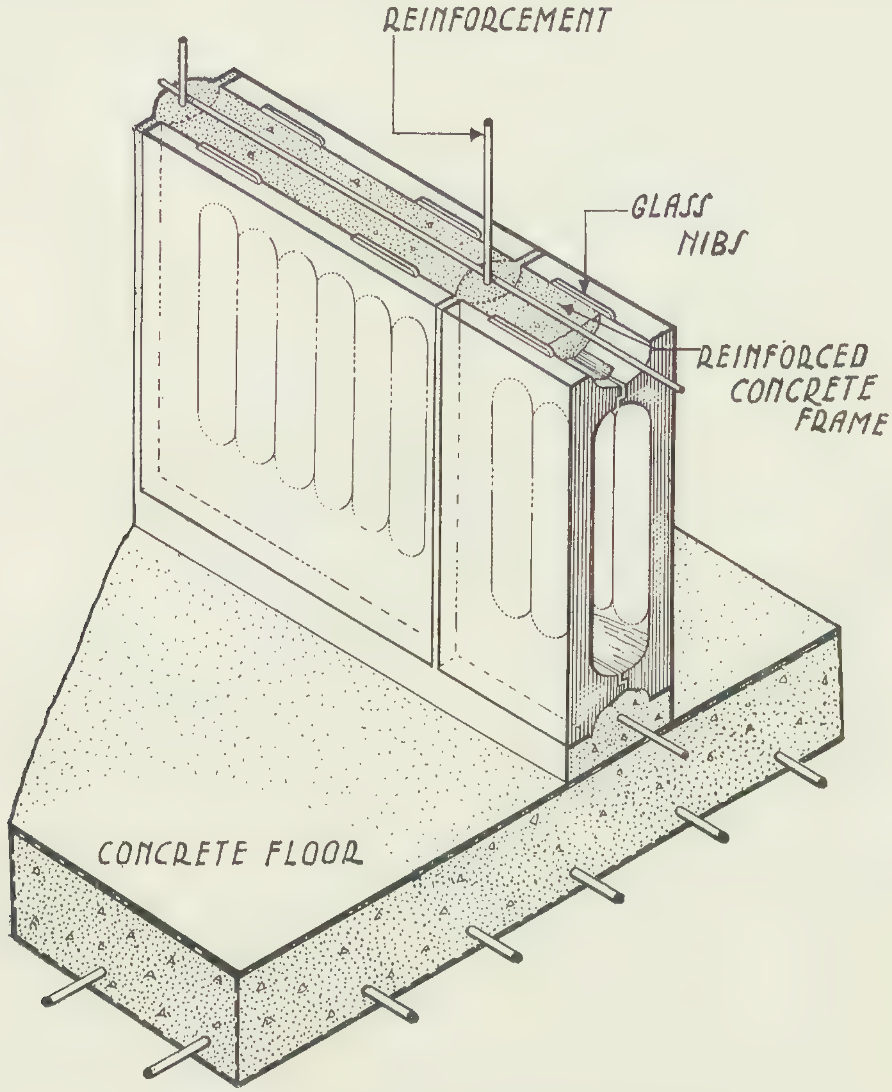

FIG. 117. CONSTRUCTION OF A GLASS UNIT PARTITION WALL

of internal partition walls, and, when used in such positions, they will produce ample diffused light and reduce sound-transmission and heat losses. The application of the glass brick in the construction of a partition wall is illustrated in Fig. 116; whilst Fig. 117 illustrates another type of glass unit which is being very largely used in the construction of partition walls.

CHAPTER VIII

FIRE-PROOFING

WHILE it is doubtful whether any building can be regarded as being absolutely fire-proof, it is important that buildings should be constructed in a manner which will render them fire-resisting.

The inability of a steel-framed structure to withstand the effects of fire is no reason why the use of steel in their construction should be condemned. The fault, if any, would be due to the method of construction and the method adopted for the protection of the structural members, rather than to the material itself.

All steel members composing the framework of structures should be protected against fire. This may be done by encasing them in fire-resisting material, such as bricks, concrete, hollow blocks, partition slabs, etc.

It has already been mentioned that the term "fire-resisting construction" may be applied to all those buildings which are built of fire-resisting materials and have floors and roofs constructed in reinforced concrete, steel and concrete, and hollow blocks.

Wood may be used for floor finishings, and firring for suspended ceilings under floors, window and door frames, sashes, doors, and internal wall finishings.

Under some building by-laws all structural steel members and steel reinforcements must be surrounded with a fire-resisting material.

In some instances steel-framed structures are allowed without this covering, but such structures cannot be included under the heading of fire-resisting structures. Reference should be made to Section 12 of the *Code of Practice for the Use of Structural Steel and other Materials in Building.*

The ability of a structure to withstand the effects of fire may be defined in terms of the time it would take for the structural members, including walls, floors, stairways, and roofs, to become unsafe or damaged to such an extent that they would be unable to fulfil their proper function as a result of the conflagration.

During recent years much attention has been given to the design and construction of fire-resisting buildings, and very useful results have been obtained from the research which has been carried out by various departments in the effort to produce materials which may be said to have fire-resisting qualities.

Materials whose function it is to protect the structural members of a building from fire, must be low conductors of heat and maintain their integrity as a protective medium. The most satisfactory insulating materials are bricks, burnt clay blocks, and light-weight concrete.

Steel may be considered as an incombustible material, but it conducts heat very readily and expands and contracts under varying temperatures. Therefore if structural steel is directly exposed to excessive heat, resulting from an outbreak of fire, the rising temperature will cause the structural members to expand. This rise in temperature, followed by the application of cold water, will cause the beams and stanchions to twist and contort, and possibly lead to the collapse of the building. It is necessary therefore to protect all structural steel with an insulative material.

As heat is conducted very slowly by bricks, burnt clay blocks, and concrete,

the expansion in these materials is slow when they are subjected to heat; therefore any of them may be used as a protective covering to the steelwork.

Porous materials are considered to have high heat-insulating values; therefore when concrete is used it is preferable to use light-weight concrete. The use of this type of concrete, however, should be limited to positions where it will act merely as a covering, and not be likely to be subjected to stresses resultant upon the application of loads. It is because of this that ordinary ballast concrete is generally used for the covering of beams and stanchions, and formed continuous with the floor slabs.

From a fire-resisting point of view, reinforced concrete structures may be considered as superior to steel-framed structures, because the steel is in smaller units and dispersed evenly throughout the mass of concrete. But if the structural steel frame is protected in a proper manner, there is no reason why it should fail in the case of fire.

When considering the employment of various materials as insulators, it is important to remember that the successful behaviour of these materials will depend very largely upon the methods adopted in their use as well as upon their fire-resisting qualities. This is very noticeable when the materials are considered as independent units. Timber, for instance, cannot be classified as incombustible material; but certain timbers may be said to have good fire-resisting qualities if they are placed in a structure in such a way that the sharp edges of the timber are protected from contact with the flames.

Protection of Stanchions. Most bricks are known to possess good fire-resisting qualities. Because of their weight they are not generally used as a protective covering to structural steel members, except when they are intended to receive and support a portion of the loads of the structure.

Because of their light weight and the ease with which they can be placed into position around structural members, burnt clay blocks have been extensively employed as a protecting medium. They may be made in a variety of shapes which will fit the contour of the steel sections. The structural members are encased with the units as in Fig. 118.

Concrete placed around the steelwork is not necessary when these specially-formed blocks are used.

When partition blocks are used they should form a permanent shuttering for the concrete in-filling. Partition blocks, however, are not so convenient for this purpose. They occupy more floor space, which is an important item in buildings of a commercial character. They may be used to advantage if provision is required for the formation of ducts for the housing of service pipes, as in Fig. 144 (*a*).

When concrete is used as the protective covering to steel stanchions, it should be placed in position simultaneously with the erection of the floors, and precede the erection of the walls. It is usual to erect wood shuttering round the stanchion and then fill the space with concrete. The resulting section of the pier is then usually square or rectangular.

The chief objection to this method is the large amount of floor space taken up by the pier.

Sometimes the concrete around the steelwork is designed to assist in supporting the loads of the structure. The concrete is then reinforced with steel rods, and a consequent saving in size of the structural steel sections is made.

The foregoing methods of encasing steel stanchions are more or less expensive

in floor space, and the shape of the pier resultant upon these methods is inconvenient, especially in industrial buildings where large floor areas with a minimum amount of pier interruption are desired. A more economical method of covering steel stanchions is to use precast concrete or plaster semi-cylindrical tubes as the form-work or shuttering for the concrete core.

These tubes are about 3 ft. long, and may be placed in pairs in a vertical

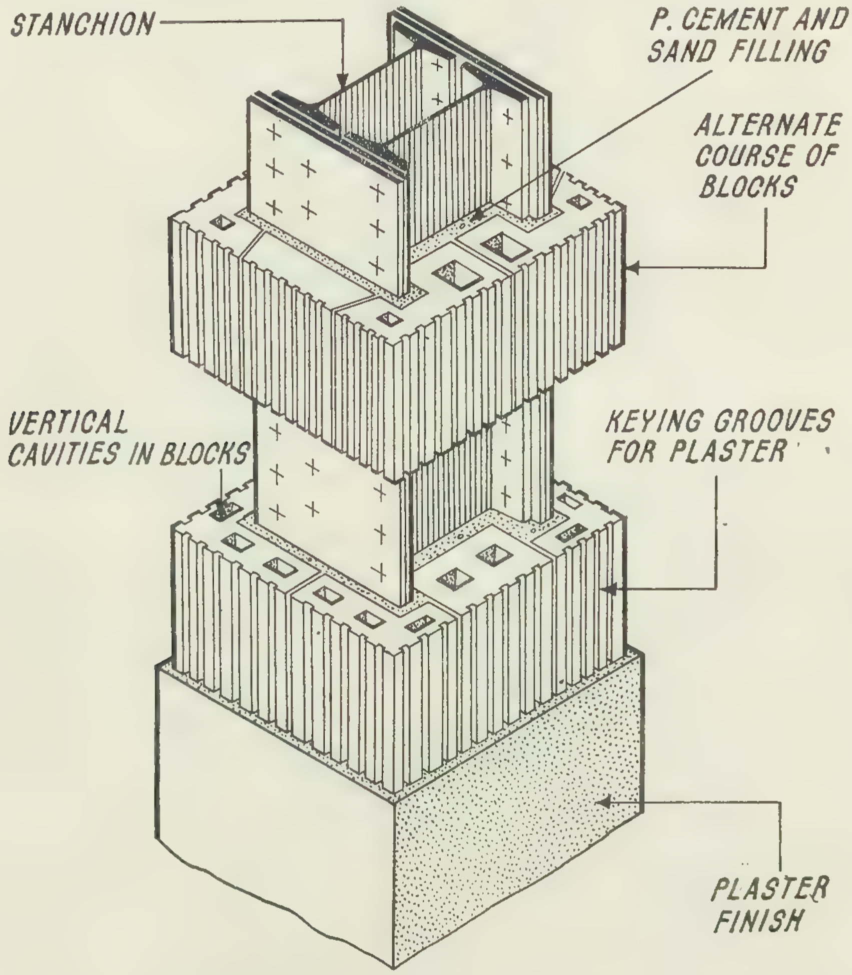

Fig. 118. Encasing Steel Stanchion with Burnt Clay Blocks

position round the stanchion and tied together with rope or wire. The space between the tubes and the steelwork is then filled with concrete.

The tubes may be removed after the concrete has set, or they may be left in position as a permanent covering. A sketch showing the construction of tubular shuttering is given in Fig. 119.

Protection of Floors. Floors are one of the principal features in fire-resisting construction.

The vertical spread of fire in a building will depend very largely upon the fire-resisting properties of the materials used in the construction of floors. Therefore it is important that all the members composing the floors should be encased in one of the protective materials already mentioned. The main beams of floors should be encased in the same manner as steel stanchions. The protective covering may be formed continuous with the concrete of the floor slab and wire

mesh or expanded metal may be wrapped round the steelwork as in Figs. 93 and 120, which show an external steel beam encased with concrete. These materials will act as a reinforcing medium for strengthening the concrete.

The selection of the fire-resisting material for the beams must be dependent upon the type of floor, and the method of construction. Specially formed burnt

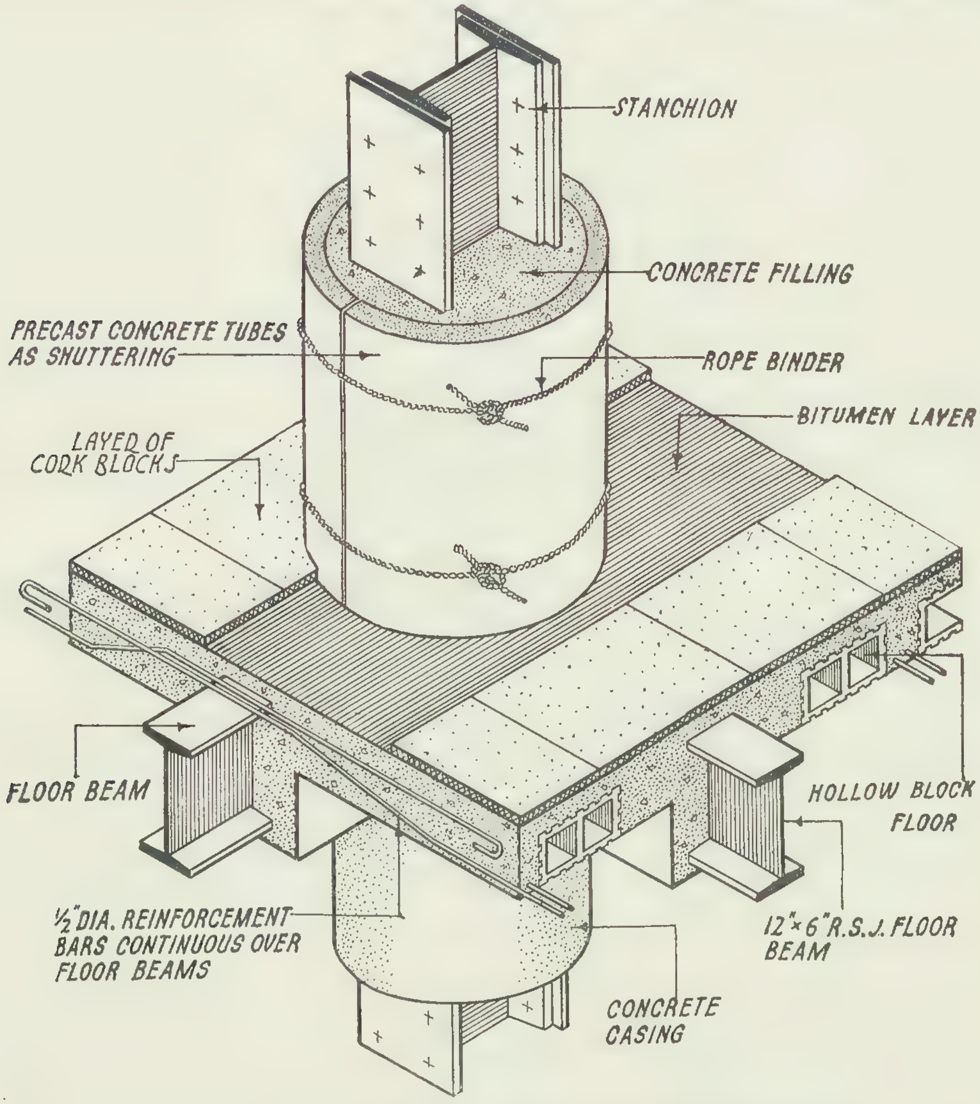

Fig. 119. Tubular Shuttering for Encasing Steel Stanchions

clay blocks are sometimes used as in Fig. 121, which shows the construction of a "King" hollow tile floor which includes specially formed blocks for covering the secondary beams or filler-joists. The encasing of a main floor beam with burnt clay blocks in combination with a hollow block floor is to be seen in Fig. 122.

Sketches throughout this book illustrate how floor beams may be encased so as to protect the structural members from the effects of fire.

Stairs. These are a very important part of a fire-resisting building.

As stairs are provided to give access to and descent from the various floors comprised in the building, they should be designed so that they may be ascended or descended with ease, and constructed so that they will offer the maximum resistance to fire.

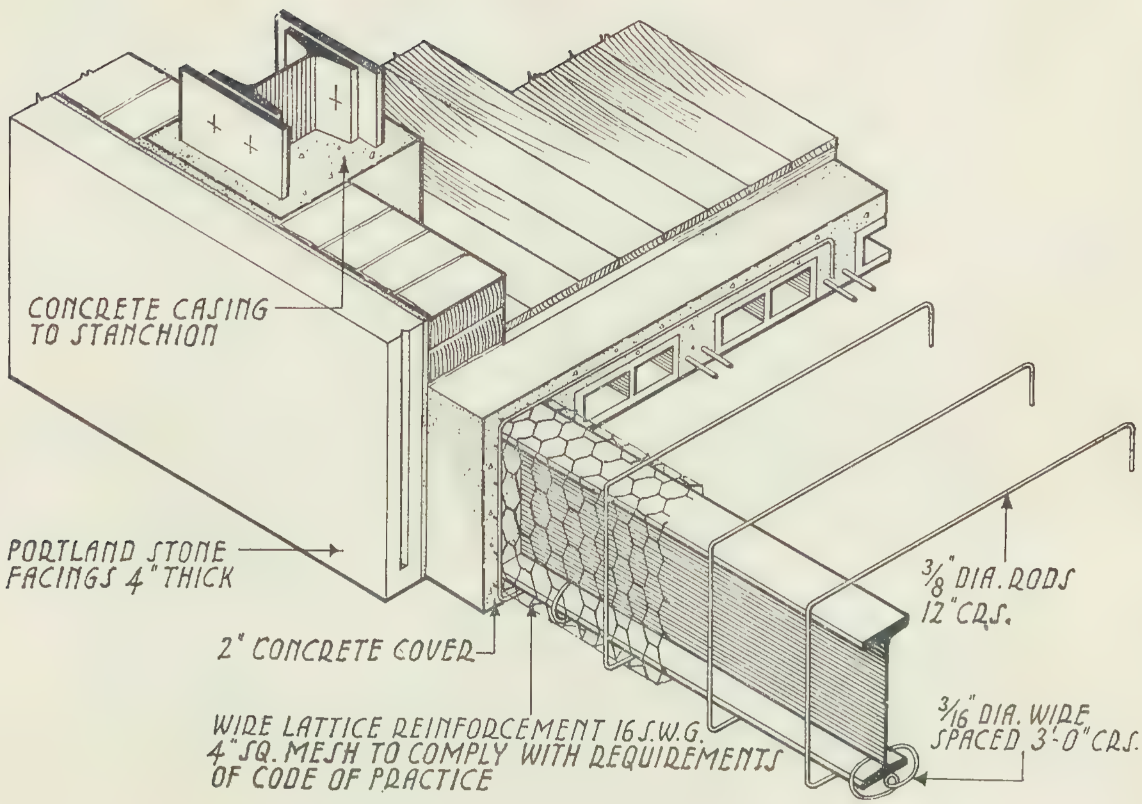

Fig. 120. Encasing Steel Beams in Concrete

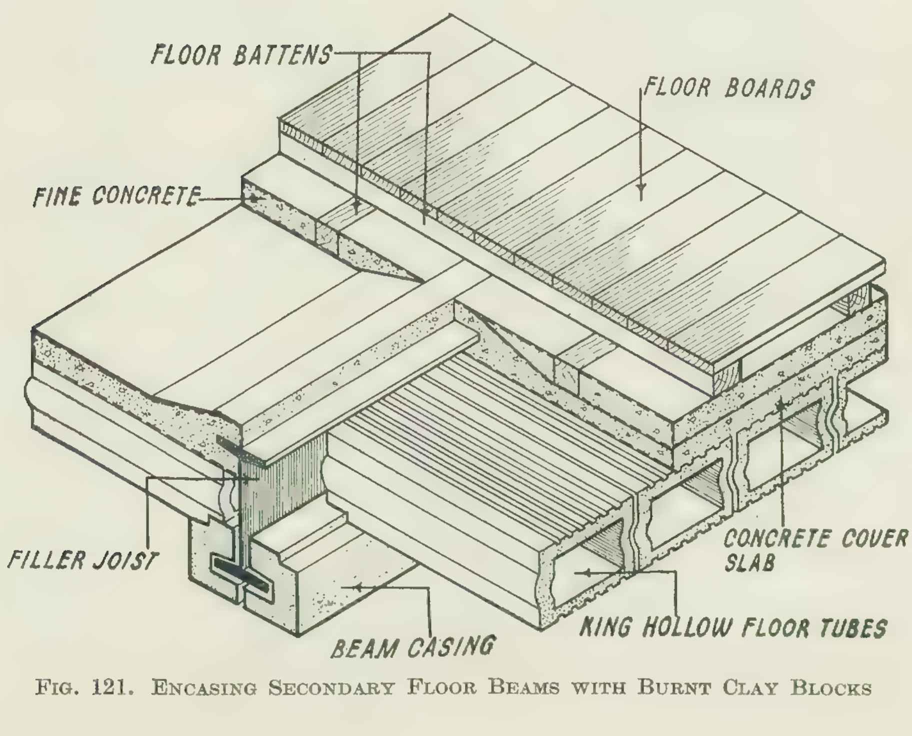

Fig. 121. Encasing Secondary Floor Beams with Burnt Clay Blocks

It is of the utmost importance that the stairway in a fire-resisting building should be constructed with fire-resisting materials, and be a monolithic structure in preference to an assembly of several units.

Reinforced concrete stairs cast *in situ*, with or without hollow blocks, appear to be the best type for fire-resisting qualities. The stairs should be constructed like floors. They should be reinforced with steel bars, placed so that they link up with the floor and landing reinforcement to form a continuous structure.

Staircases should be enclosed and separated from main corridors, otherwise the staircase will act as a shaft and tend to encourage the spread of fire to the

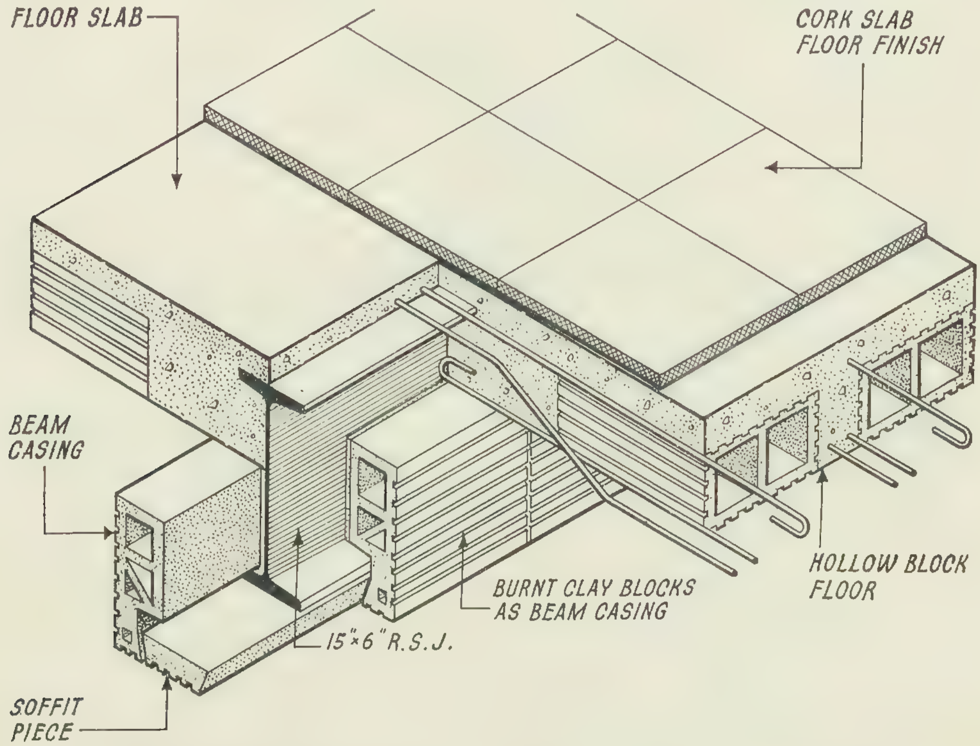

Fig. 122. Encasing Main Floor Beams with Burnt Clay Blocks

various floors. All doors leading on to the staircase should be of a fire-resisting character, and metal trim and metal sheathed doors are well adapted for the finishings to openings which connect direct on to the stairways. There should be a proper ratio of tread to riser, and resting places or landings should be provided in the height between floor and floor.

Stairs should be wide enough to enable traffic to proceed both up and down simultaneously.

Wood stairs are still in general use in domestic construction. They are easy to erect and are more in keeping with the internal design of such buildings.

For buildings of a commercial character or when a stairway is likely to be used by a number of people it is desirable that a more fire-resisting form of construction be adopted.

Owing to mechanical appliances, such as lifts, etc., which are essential items in the equipment of buildings having multiple floors, or very tall buildings, stairs are not used as they once were. Even under these conditions the provision of an efficient stairway is most important. Reinforced concrete stairs, cast *in situ*,

with or without hollow blocks, appear to be the best type of fire-resisting stair. Such stairs are constructed in the same way as floors and can be regarded as being inclined beams and slabs. The reinforcement bars in the stairs are placed

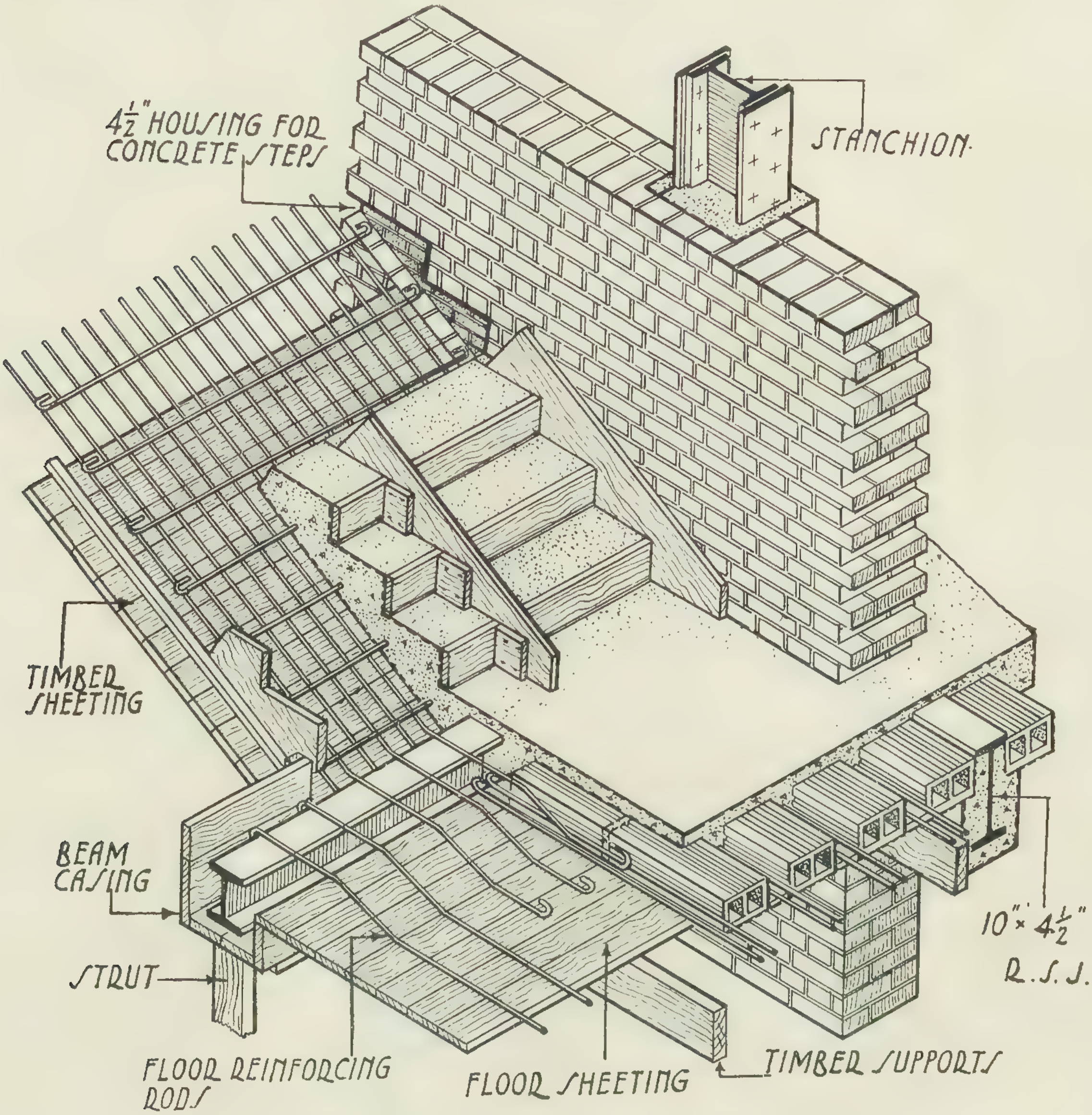

Fig. 123. Construction of a Reinforced Concrete Stairway

so that they link up with the floor and landing reinforcement and are continuous with them.

Fig. 123 shows the construction of a reinforced concrete stairway. This illustrates the method of reinforcement and of linking up with the floor slab, also the necessary housing in the brick wall of the staircase. A portion of the wood shuttering and form-work for the support of the stairway during construction is seen in the sketch.

The advantage of securing the maximum amount of light at the vital points of a staircase has been long recognized. The provision of this extra light has formerly been dependent upon the construction of the walls and fabric of buildings. With modern methods in design and the development of reinforced

concrete, it has become an easy matter to incorporate in buildings vertical glazing surfaces which extend uninterruptedly throughout the height of the building and almost independently of the various floors.

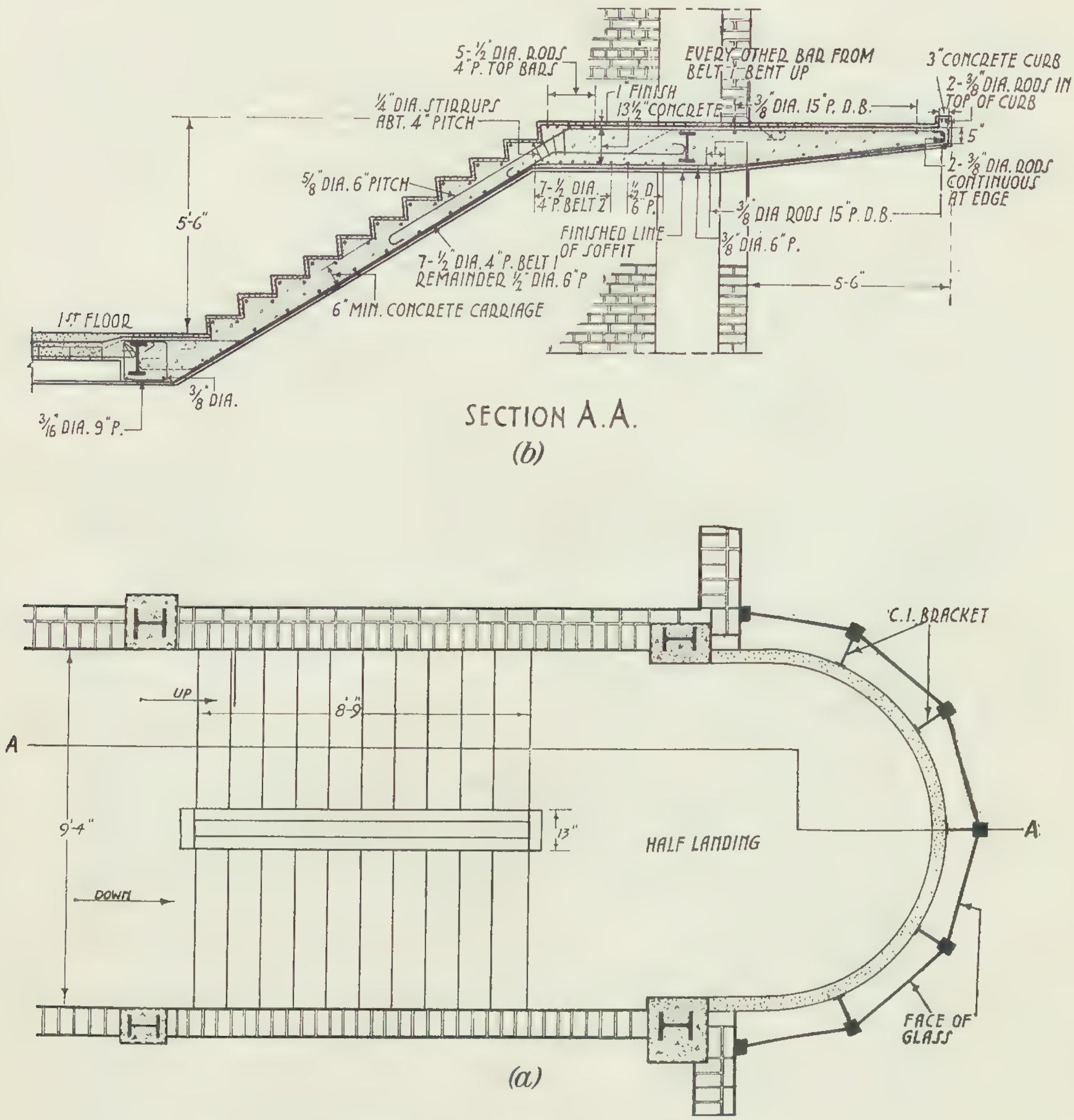

Fig. 124. Construction of Reinforced Concrete Stairway

(a) Plan of stairway.
(b) Section of stairway.

Figs. 124 (*a*) and 124 (*b*) show the plan and section of a typical reinforced concrete stairway, including the construction of a semi-circular balcony, which is cantilevered out from the half-space landing. The balcony is finished with a reinforced concrete curb at the extreme edge and the glazing (which is in a metal frame) is bracketed out from the balcony; thus the maximum glazing area at the landing level is provided.

An illustration of the construction of the stair and cantilevered landing is given in Fig. 125, and a detail of the glazing mullion in Fig. 126.

Lifts are an essential part of the equipment of modern buildings; in fact they

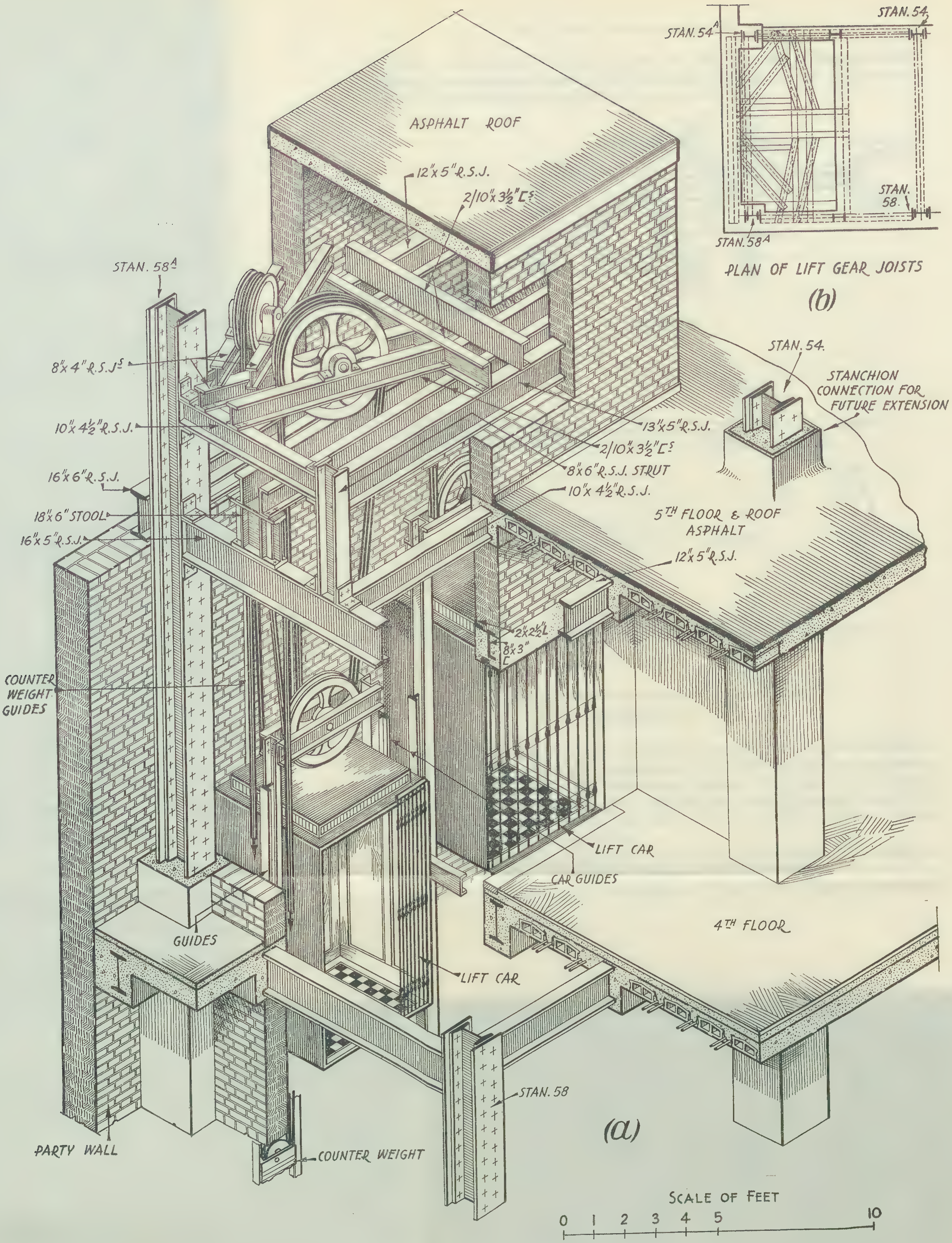

FIG. 127. CONSTRUCTION OF PASSENGER LIFT

(a) Constructional sketch of lift.
(b) Plan of lift gear joists.

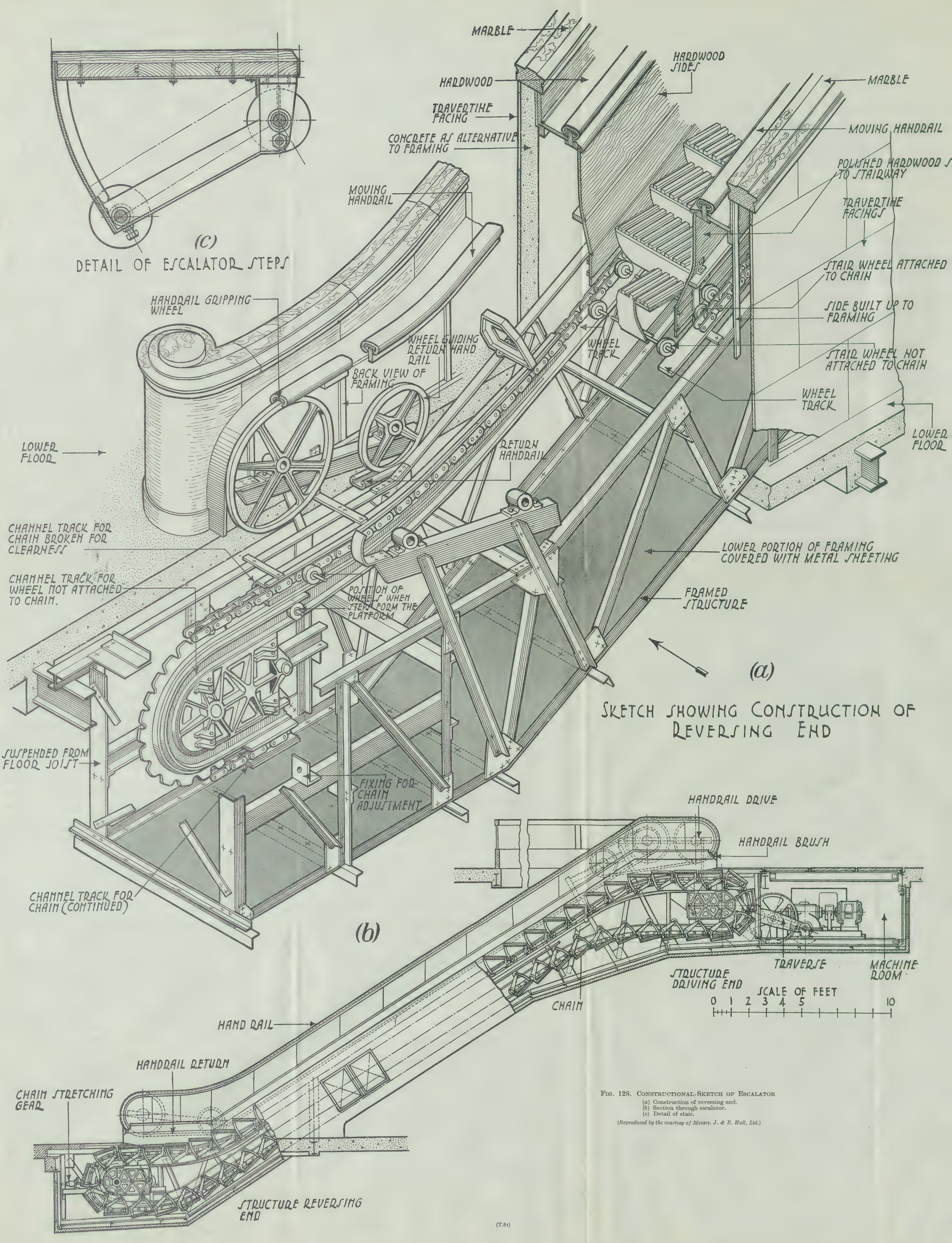

FIG. 128. CONSTRUCTIONAL SKETCH OF ESCALATOR
(a) Construction of reversing end.
(b) Section through escalator.
(c) Detail of stair.

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have, in conjunction with steel and reinforced concrete, made tall buildings possible. They should be situated so as to give direct access to and from exits and entrances.

For this reason passenger lifts are often placed in the well portion of main

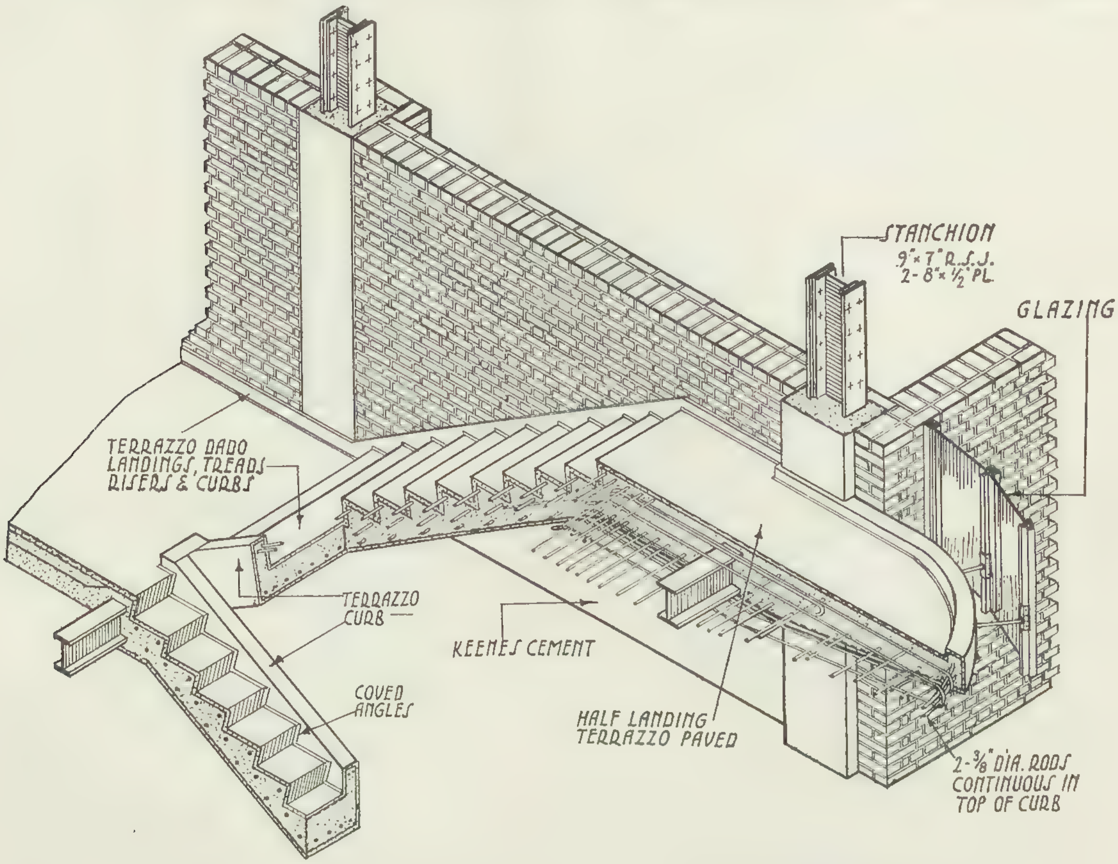

Fig. 125. Construction of Stairway and Cantilevered Landing

stairways, but from a fire protection point of view such positions are not considered the best as there is a natural tendency for the fire to spread vertically by way of the staircase shaft. They are better placed near to the main stairways but separated from them by enclosing the lifts in specially formed compartments.

The isolation of the lifts will provide additional means of escape for the occupants of a building should an outbreak of fire occur.

A sketch illustrating the construction of the top portion of a twin-cage lift in conjunction with a steel-framed structure is given in Fig. 127 (*a*) and (*b*).

Escalators. Escalators are becoming more generally installed in large shops and departmental stores. They are convenient to passengers and they accelerate the flow of traffic from one floor to another, which is a very important item. Some building

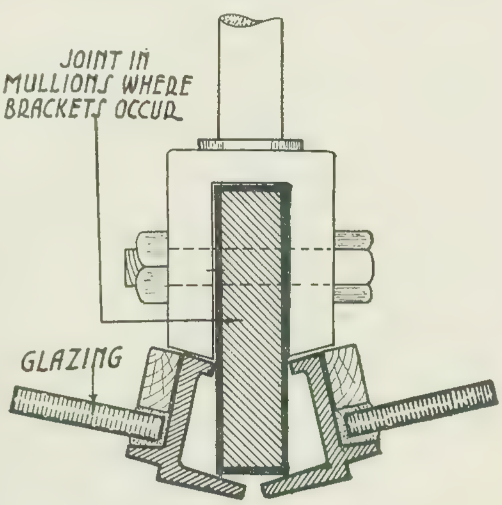

Fig. 126. Detail of Glazing Mullion

by-laws will not permit of their installation above the ground floor. This restriction is based chiefly upon the difficulties connected with the prevention of the vertical spread of fire. There is naturally a direct contact from one floor to another at the head or top portion of the escalators, but this objection could be overcome by providing movable or sliding hatchways which could be made to operate in the event of an outbreak of fire.

The construction of escalators involves a considerable amount of ingenuity and although they have been installed in buildings throughout America they are of fairly recent adoption in England, due chiefly to the restrictions already

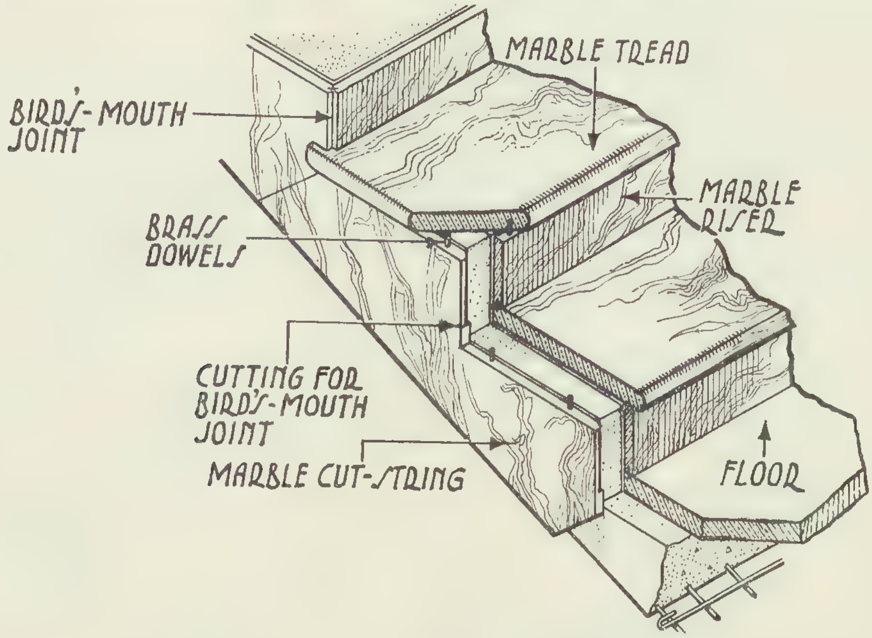

Fig. 129. Marble Covering to Concrete Stairs

mentioned. A sketch illustrating the construction of an escalator suitable for installation in a large departmental store is given in Fig. 128 (*a*), (*b*) and (*c*).

Stair Coverings. The concrete should form the base upon which the finished stair is formed.

There are occasions, such as for service stairs, where the concrete may be rendered to form the finish surface. In such instances an abrasive composition is incorporated in the material so as to form a non-slip tread and the edge of the step is rounded.

There are many materials which may be considered as being suitable for covering concrete stairs. Among them are marble, terrazzo, rubber, and teak. For main stairs of importance, and in public buildings where the stairway is a prominent feature of the internal design, it is usual to cover the concrete core with marble slabs. A sketch illustrating the construction and application of marble stair coverings is given in Fig. 129. The stairs in Fig. 125 are shown covered with terrazzo.

There are many kinds of metal stairs now in use. Steps are designed as special units which can be interlocked with one another to form a stairway. The treads may be covered with one of the covering materials already mentioned, or finished with hard wood strips or buttons.

Also there are many kinds of built-up stairs composed of precast concrete units. These are very suitable in many situations since they are economical and easily made.

CHAPTER IX

SOUND-PROOFING

The question of sound-proof construction is of great importance and a necessary requirement of modern building.

Although sound insulation is not new, it is only during recent years that any serious attention has been directed to the prevention of sound transmission by walls, floors, partitions, windows, and roofs.

The lack of quietness due to the increase of noise-producing instruments, and of vibrations caused by modern transport, calls for special investigation to secure acoustic isolation for the tenants of the buildings of to-day.

Sound transmission occurs chiefly through window openings, door openings, and ventilators; and by the agency of ducts, service pipes, conduits, etc., and framework of the structure. There are three ways in which sound is transmitted, namely—

(1) Structure-borne.

(2) Air-borne.

(3) Occupant-borne, through contact noises or vibrations.

Insulating Structures. Structure-borne sounds are transmitted by vibrations travelling through the medium of the structural steel framework. These vibrations can be reduced by insulating stanchion bases and beam connexions. Stanchion bases can be insulated by bedding them upon a layer of compressed cork or lead and asbestos. Similar pads can be used between the joint connexions of beams, etc.

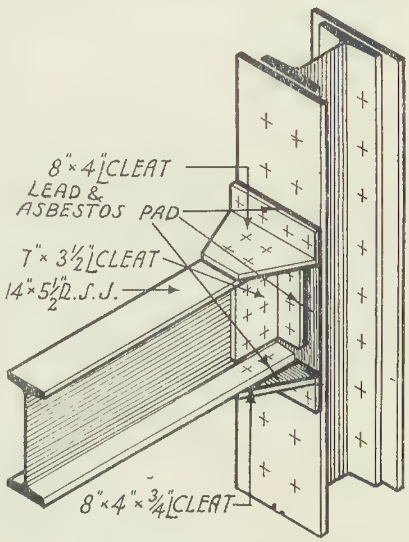

FIG. 130. INSULATION OF STRUCTURAL MEMBERS

In each case the connexions should be secured with bolts in place of rivets, and compressed asbestos and lead washers and sleeves for the bolts should be used as in Fig. 130.

Lifts, escalators, and mechanical ventilating fans may be considered as essential items in modern building equipment. They are all sound transmitters; therefore it is necessary that the connexions of these mechanical units with the structural framework shall be insulated.

This may be done by placing asbestos pads between the connexions as in Fig. 131, which shows how the framework of a lift may be secured to the stairway without being connected to the steelwork. The machinery used for driving lifts, ventilating fans, etc., may be bedded upon pads of compressed cork instead of direct upon their concrete foundation. This will produce a resilient foundation bed and therefore reduce vibration very considerably.

Sound-proofing External Walls. Air-borne sounds may be reduced by increasing the thickness or weight of the material of the dividing walls, or by lining the internal surface of external walls with materials of known sound-insulating qualities without increasing the thickness of the wall. Fig. 132 shows

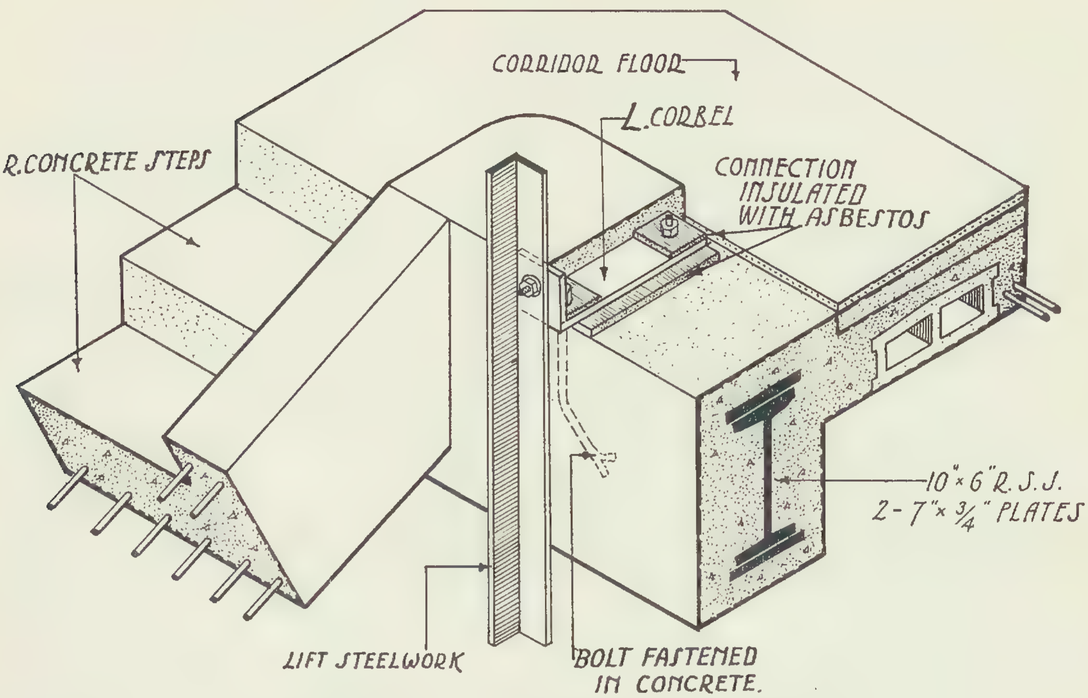

Fig. 131. Method of Insulating Lift Framework

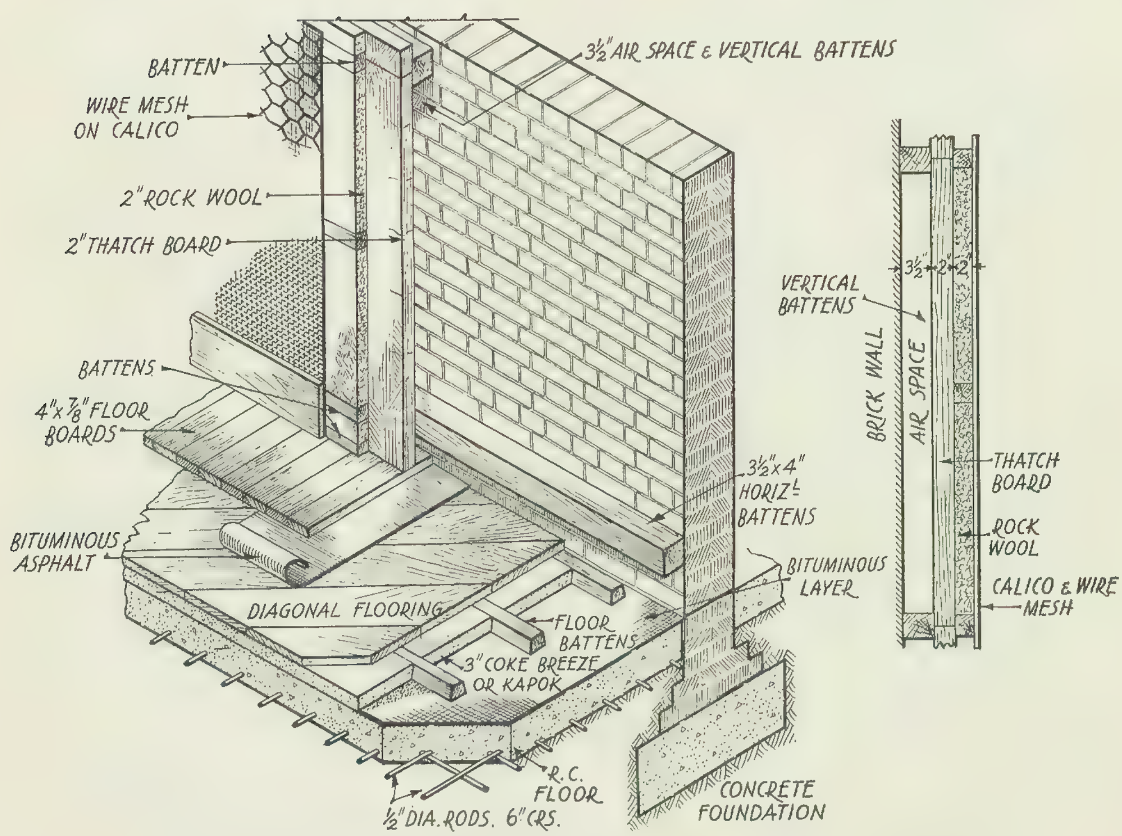

Fig. 132. Sound-proofing Brick Wall and Concrete Ground Floor

how a comparatively thin external brick wall may be lined with insulating materials to obtain sound-proof qualities.

The method shown in this example was adopted for the construction of a film studio where external sound insulation is of the utmost importance. The lining of the wall consists of fastening wood battens to the internal face of the brick wall, then a sheeting of thatch-board. This is covered with a 2 in. layer of rock wool, and the surface finish is obtained by a layer of calico covered with wire

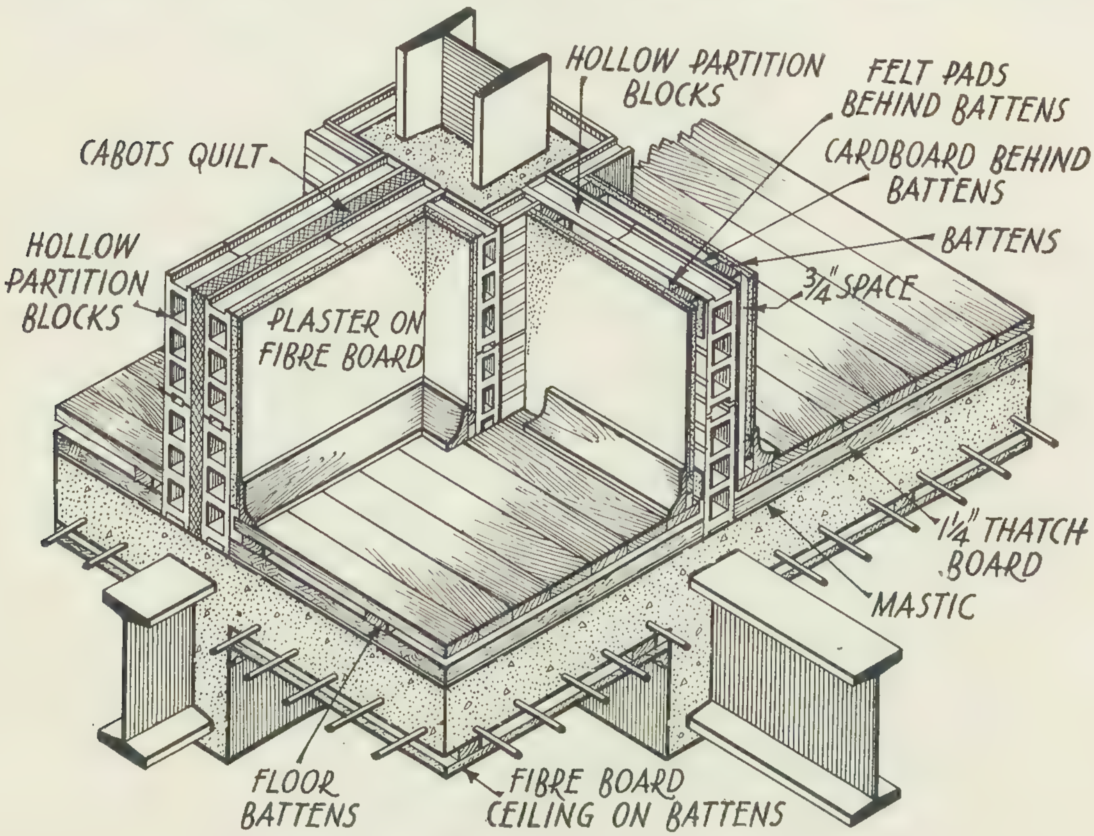

FIG. 133. SOUND-PROOFING HOLLOW BLOCK PARTITION WALL AND REINFORCED CONCRETE UPPER FLOORS

mesh. The battens which support the rock wool form the grounds for securing the finishing surface material.

Air-borne sounds can be transmitted through the openings in walls or ventilation grills, as well as through the dividing medium itself.

Whilst the weight and thickness of a wall will help to reduce sound transmission, modern construction does not allow the use of superfluous walling material. The maximum amount of floor space is an essential requirement of a modern building, therefore other means must be adopted to prevent sound ransmission.

One of the essential characteristics of modern internal wall and partition wall construction is that the wall should be light in weight and, if desired, easy of removal. There are many materials of known sound-resisting qualities which may be incorporated in the construction of partition walls, but their effectiveness will depend upon the method then adopted. Felt, fibre-boards, cork, quilted materials, and acoustic plaster are among them.

Sound-proofing Partition Walls. The insulating value of a partition wall will depend chiefly upon the method adopted in its construction. A wood-stud partition, constructed as in Fig. 111, will have fairly good insulative qualities, but improved results will be obtained if a layer of felt is fastened on one side of the partition and the surface layer on the other side rests against felt pads fastened to the edge of the wood studs as in Fig. 90.

A single hollow block partition wall will have good insulating qualities if it is covered with some form of material for that purpose instead of being rendered with plaster direct on to the surface of the slabs. The method shown in Fig. 133

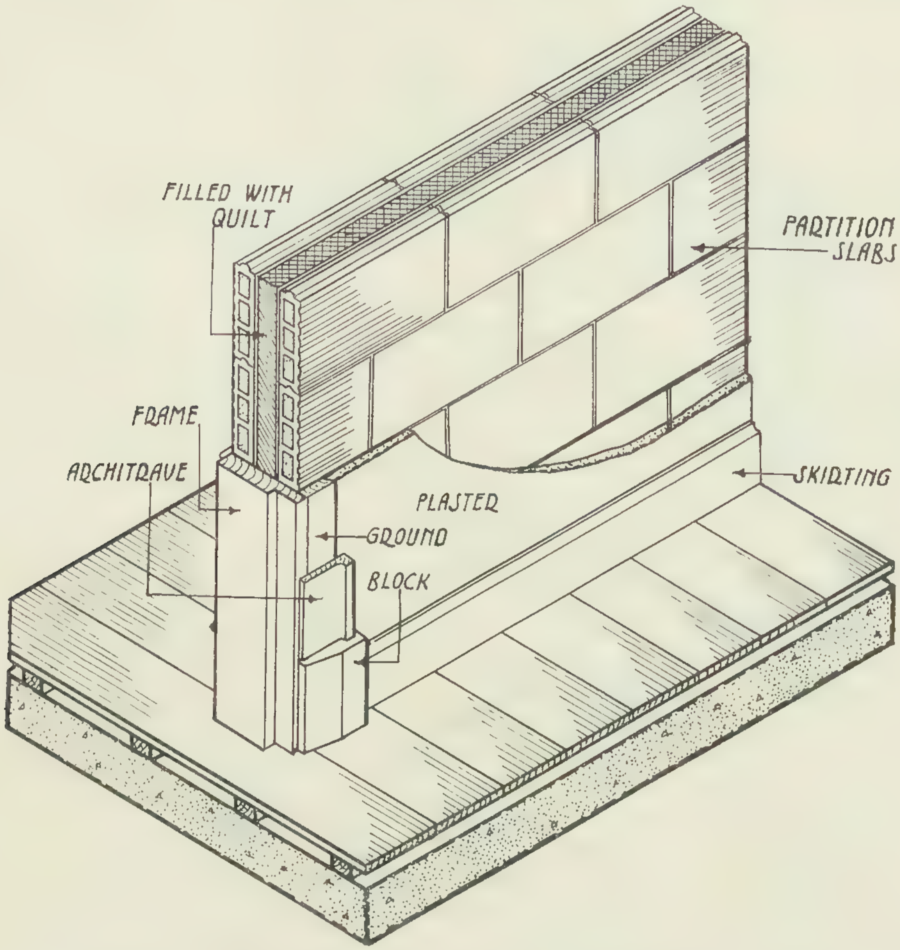

FIG. 134. SOUND-PROOFING HOLLOW BLOCK PARTITION WALLS

will improve the sound insulating qualities. Vertical wood battens are fastened to the partition blocks, but they are cushioned upon felt pads. The wall area is then covered with cardboard sheets and the surface finished with pressed fibre wall-boards.

A cavity partition wall constructed with hollow blocks may be rendered ineffective from a sound insulating point of view, if the leaves of the partition wall are allowed to fill the space or panel between the structural steel members, even though the cavity between the walls is uninterrupted throughout. The leaves of the partition wall will act as diaphragms, and amplify the sound waves, although the enclosed cavity between the leaves would normally tend to reduce

sound transmission. Such construction will produce a partition wall having poor insulating qualities, and it will be quite ineffective as a sound-proof wall unless the leaves are built on or surrounded with an insulative cushion.

As a further precautionary measure the cavity can be lined with a vertical layer of quilted material as in Figs. 134 and 135. Unless openings in cavity partition walls are properly constructed they will nullify the efforts made to secure sound insulation.

Fig. 115 illustrates a suitable method of construction around a doorway opening in a hollow block cavity partition wall. A layer of felt is attached to the door framing and inserted in the cavity surrounding the opening.

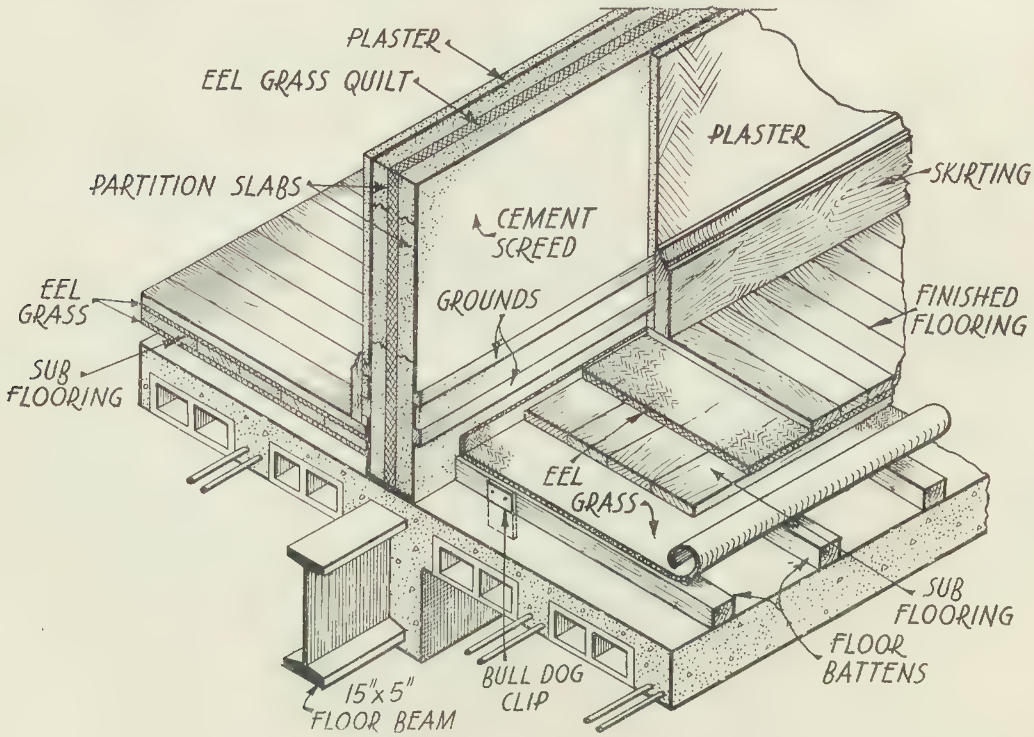

FIG. 135. SOUND-PROOFING PLASTER SLAB PARTITION WALL AND HOLLOW BLOCK UPPER FLOOR

Fig. 135 shows the construction of a sound-proof partition wall built with plaster slabs. The space between the slabs is filled with a layer of eelgrass and the outside surface of the slabs is screeded with cement and then the finished plaster surface is formed.

A sketch showing the construction of a hollow block cavity partition wall, as recommended by the Building Research Station, is given in Fig. 136.

The leaves of this partition are built upon wood bearers which rest upon a layer of cork, and the tops of the leaves are finished against a layer of felt.

Sound-proofing Floors. Contact noises are transmitted by floors and result from people walking over or dropping articles on the floors, or from noises resulting from vibration caused by working machinery or trade processes carried on within the building.

Timber floors may be insulated by incorporating layers of cellular material above and below the timber joists, as in Fig. 137. A felt blanket laid on the joists and covered with a layer of eelgrass or thatch-board will assist insulation. Another layer of eelgrass or thatch-board may be fastened to the underside of the

timber joists, and the ceiling formed with pressed-fibre board. These will render a timber floor practically sound-proof.

As concrete and hollow block floors are all more or less sound transmitters, very much will depend upon the type of floor finish if sound-proof qualities are desired; therefore care must be taken in the construction and in the material selected for the floor finishings. When wood blocks or boards are laid direct upon

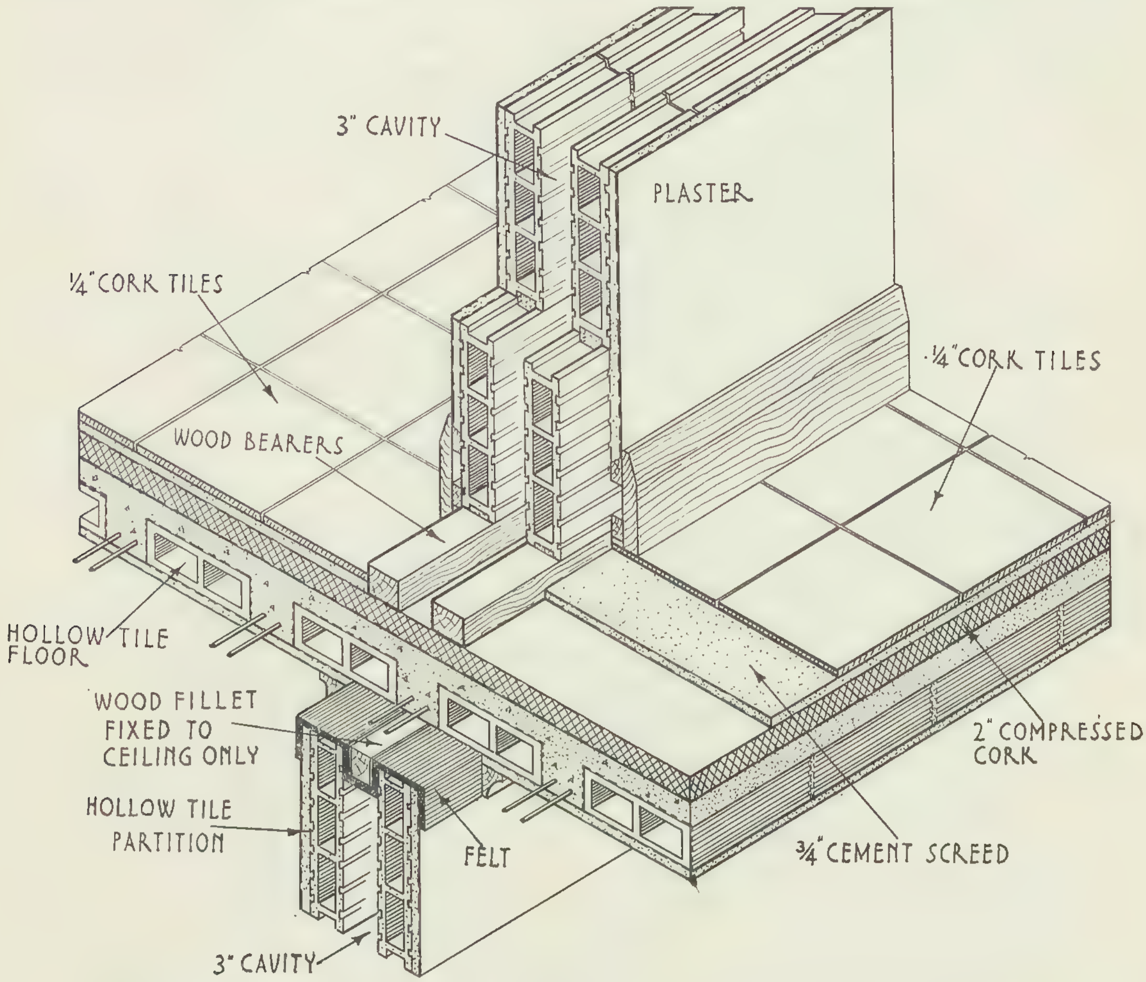

Fig. 136. Sound-proofing Floors and Hollow Block Cavity Partition Wall

a concrete floor slab, the floor does not possess good insulative qualities, for mechanical vibrations can be transmitted from the floor surface to the room below.

A better method is to lay the wood blocks upon a layer of cork or to fasten wood battens to the surface of the concrete floor slab, and then lay floor boards upon the wood battens, thus forming a space for the circulation of air between the floor finishings and the structural floor.

The method recommended by the Building Research Station is to incorporate a membrane layer of compressed cork. The cork is placed immediately upon the concrete floor; upon it a layer of cement screeding, and the floor finished with cork tiles laid directly upon the cement screed as in Fig. 136. The incorporation of the cork layer tends to produce resilience throughout the floor, and therefore insulates the rooms beneath from transmission of contact noises. The construc-

tion of a sound-proofed hollow tile floor is shown in Fig. 135. A reinforced concrete upper floor may be sound-proofed by adopting the method shown in Fig. 133.

It is usual for floor beams to project below the underside of floor slabs, but Fig. 138 illustrates the construction of a floor when the floor slab is formed level with the underside of the floor beam casing, thus providing an uninterrupted ceiling surface to the rooms below. The floor finishing is built up to the required height upon a series of wood joists which are placed upon concrete stools.

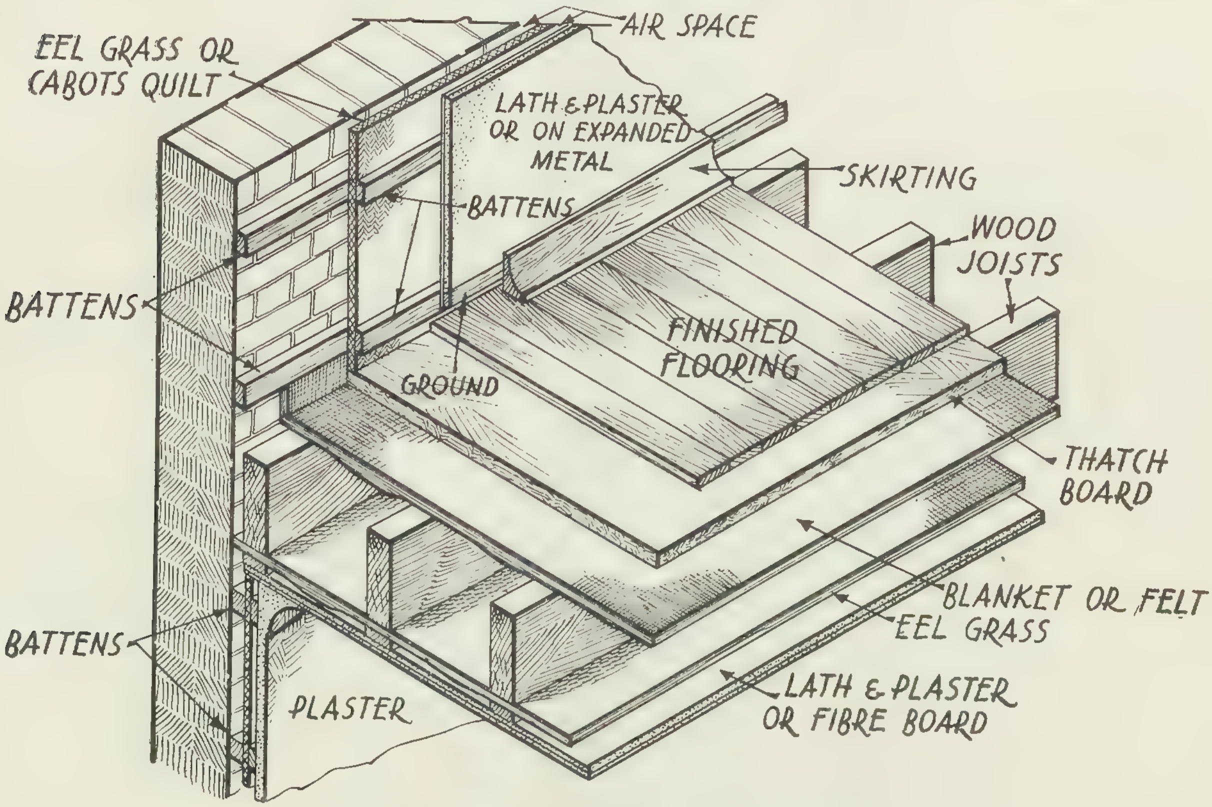

Fig. 137. Sound-proofing Timber Upper Floors

This construction may appear to occupy much space; but it does not require the inclusion of suspended ceilings to house the service ducts, because the space between the top of the floor slab and the underside of the flooring may be used for secreting ventilating ducts, service pipes, conduits, etc. This reverse construction will also produce a floor which has high sound insulative qualities.

This method of floor construction was adopted at the new University of London buildings.

Another method of floor construction is shown in Fig. 139. The floor battens rest upon rubber insulators or cushions instead of being fastened to the structural floor, thus isolating the floor finishings from the structural floor slab. This method creates a *floating floor*. It is not attached to the floor slab and is insulated from the surrounding walls by the inclusion of a cork strip. This is placed at the ends of the battens and against the wall surface as shown in the sketch.

Suspended Ceilings. Suspended ceilings assist very largely in preventing the transmission of sound through floors to the rooms below. The degree of insulation depends upon the type of construction and the materials used.

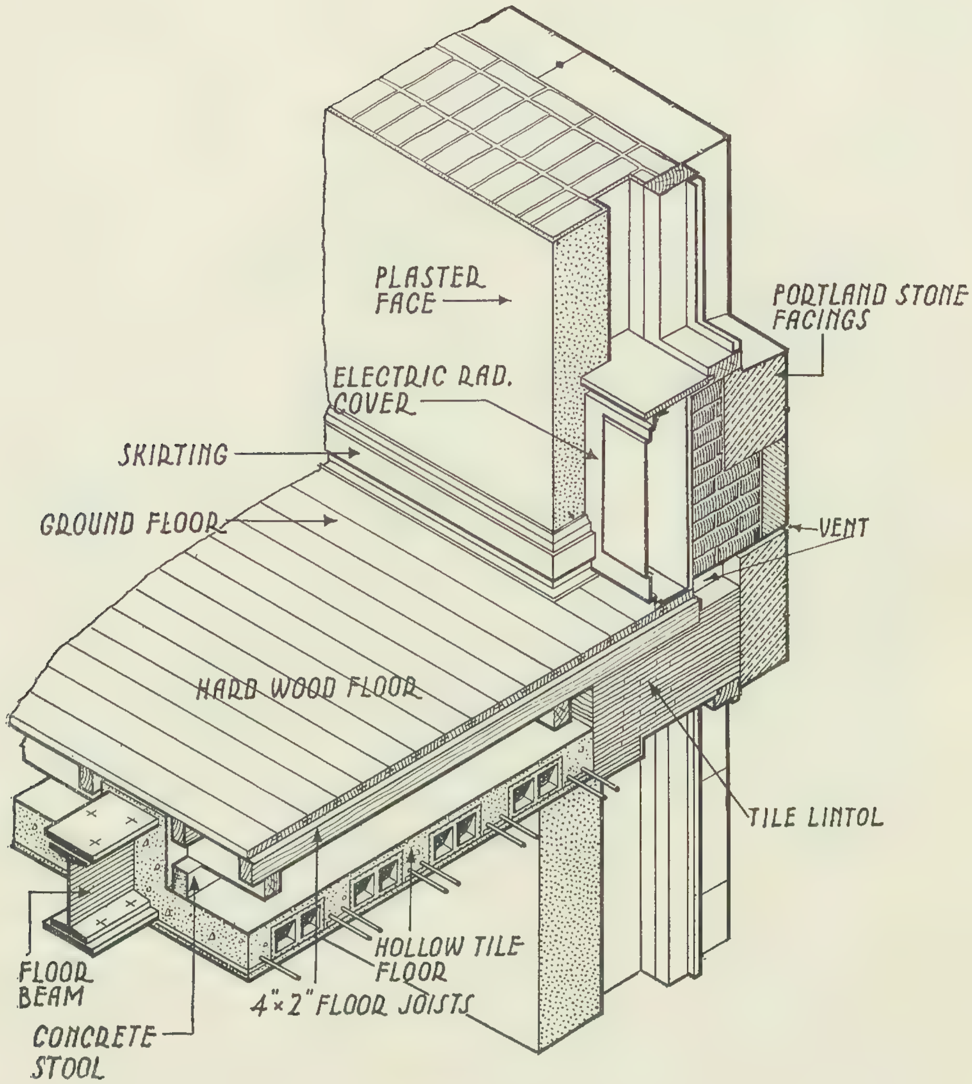

Fig. 138. Sound-proof Hollow Block Floor

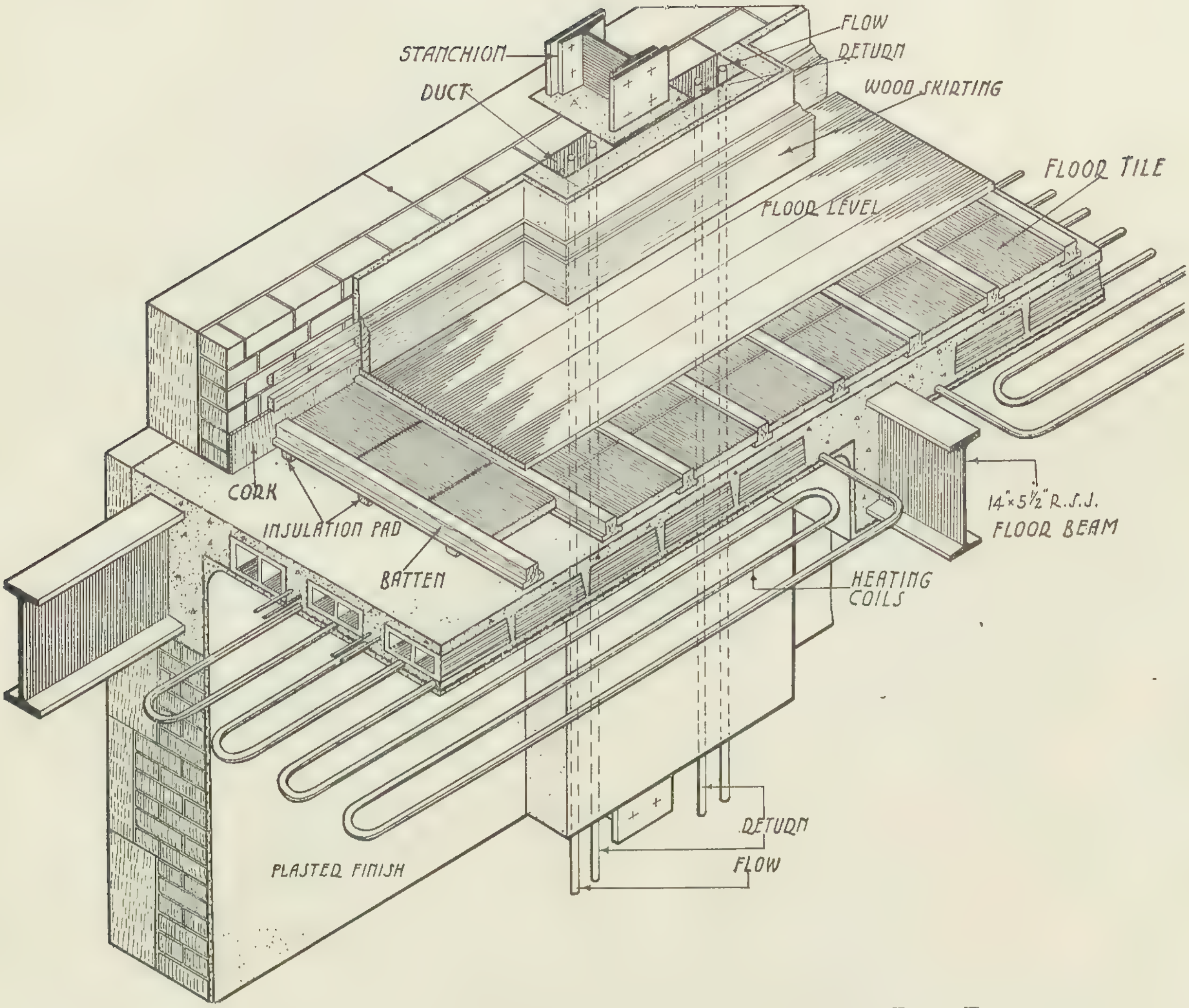

Fig. 139. Sound-proofing Hollow Block Floors and Panel Heating Pipes Embedded in Floor Slab

It is essential that a definite break of structural contact be made between the structural floor and the suspended ceiling.

Whilst the suspended ceilings which are supported upon wood framing will have good insulating qualities, the construction should incorporate a layer of felt, fibre-board, or acoustic plaster.

Ceilings are usually suspended from concrete and hollow block floors by metal

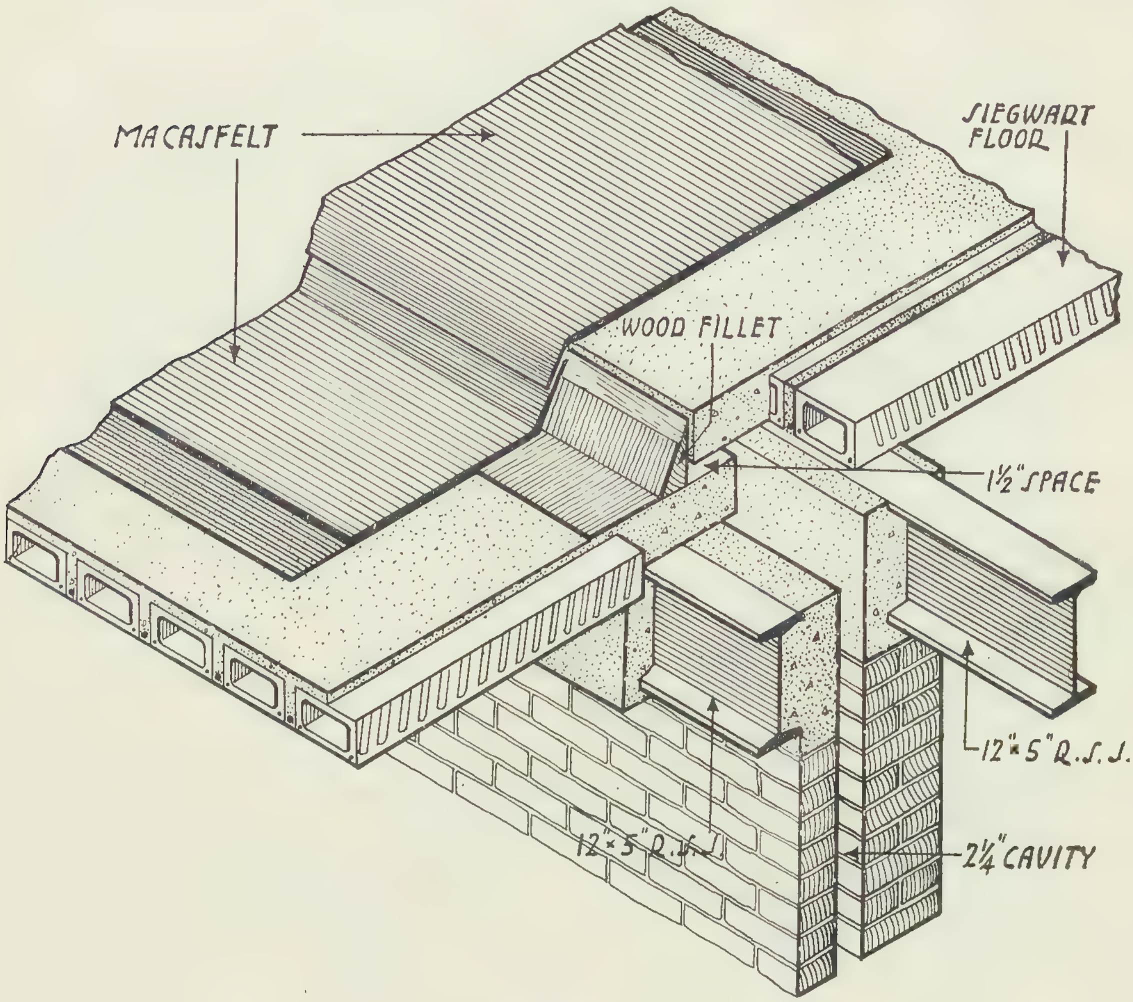

FIG. 140. SOUND-PROOFING ADJOINING ROOFS

hangers as shown in Fig. 141. The hangers are placed in position whilst the floor is being laid and are afterwards looped round metal bars to which the ceiling is attached. This method will not produce the best results; for in it there is direct structural contact between the floor and the suspended ceiling.

A better method of construction is shown in Fig. 142. Special fittings or racks are placed on the wood shuttering before the floor is laid. These are concreted in the floor slab and form the connecting device for the metal hangers. When the floor shuttering has been removed, metal hangers are connected to the racks. Pins and washers which are made of an insulating material are placed in the joints of the metal connexions, thus insulating the ceiling framework from the structural floor. Film studios require complete sound insulation; therefore it is necessary to insulate the floors and roof as well as walls.

Fig. 132 illustrates how a concrete ground floor can be rendered sound-proof. Floor battens are laid upon the asphalt layer which covers the concrete floor slab. The spaces between the battens are filled with coke breeze or quilting. Floor boards are fastened to the top of the battens, the boards being laid in a diagonal direction and covered with a layer of bituminous sheeting. The floor boards which form the floor surface are laid direct upon the bituminous sheeting.

Fig. 140 shows how contact with an adjoining room may be broken in the construction of the roof. It would be futile to provide a cavity wall separating

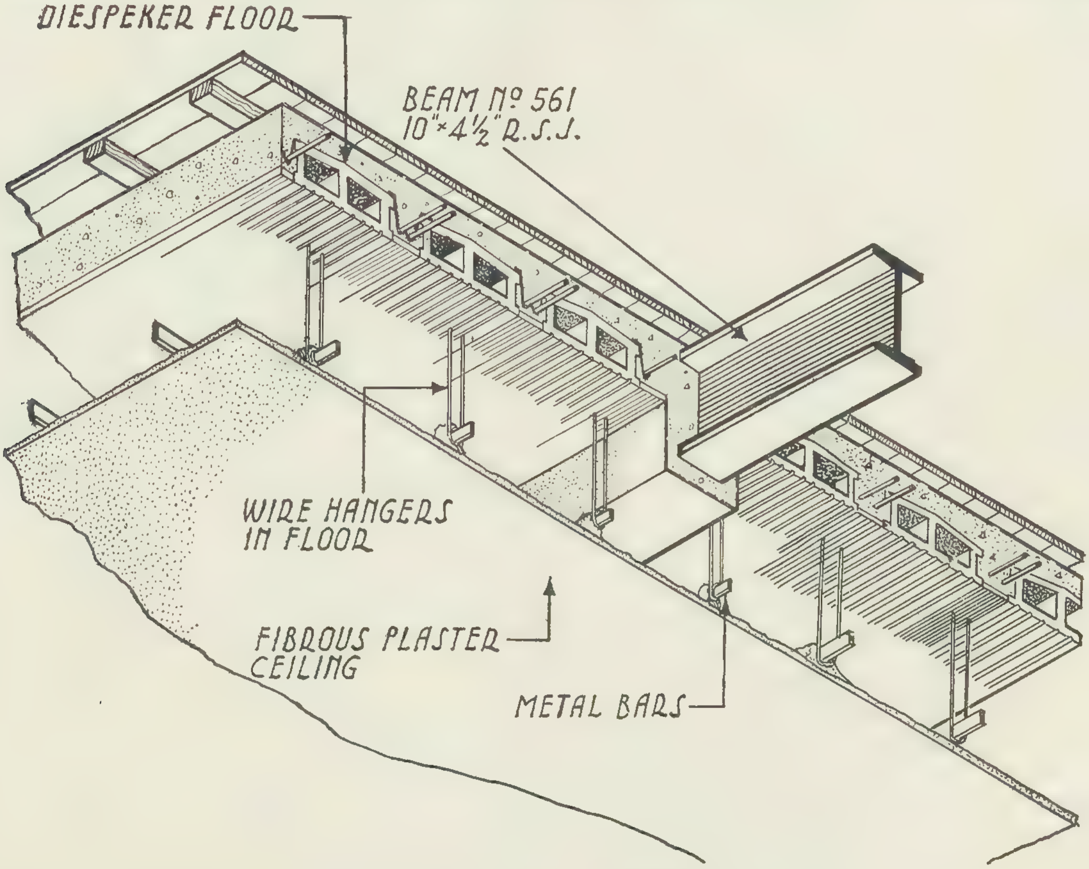

Fig. 141. Construction of Suspended Ceilings

the two apartments, if the roof slab or the structural roofing members were continuous over both apartments. The construction shown in the sketch is a suggested method and can be adapted to suit any particular circumstance.

Sound-proofing Windows. It is very difficult to prevent sound transmission through windows, but the amount of transmission will be reduced considerably if the framing is constructed so that it is practically air-tight.

This is almost an impossibility in practice, because the provision of moving sashes is essential for various purposes. The provision of double glazing, with an air space between the sheets of glass, will tend to reduce sound transmission. Window construction of this sort is expensive, and the extra benefit is nullified directly the windows are opened. Fig. 143 shows the construction of a metal window frame designed to accommodate double glazing.

Although this type of window frame will not prevent the transmission of sound, much benefit is derived from its use, especially if the panes of glass of the inner and outer windows are of a different thickness.

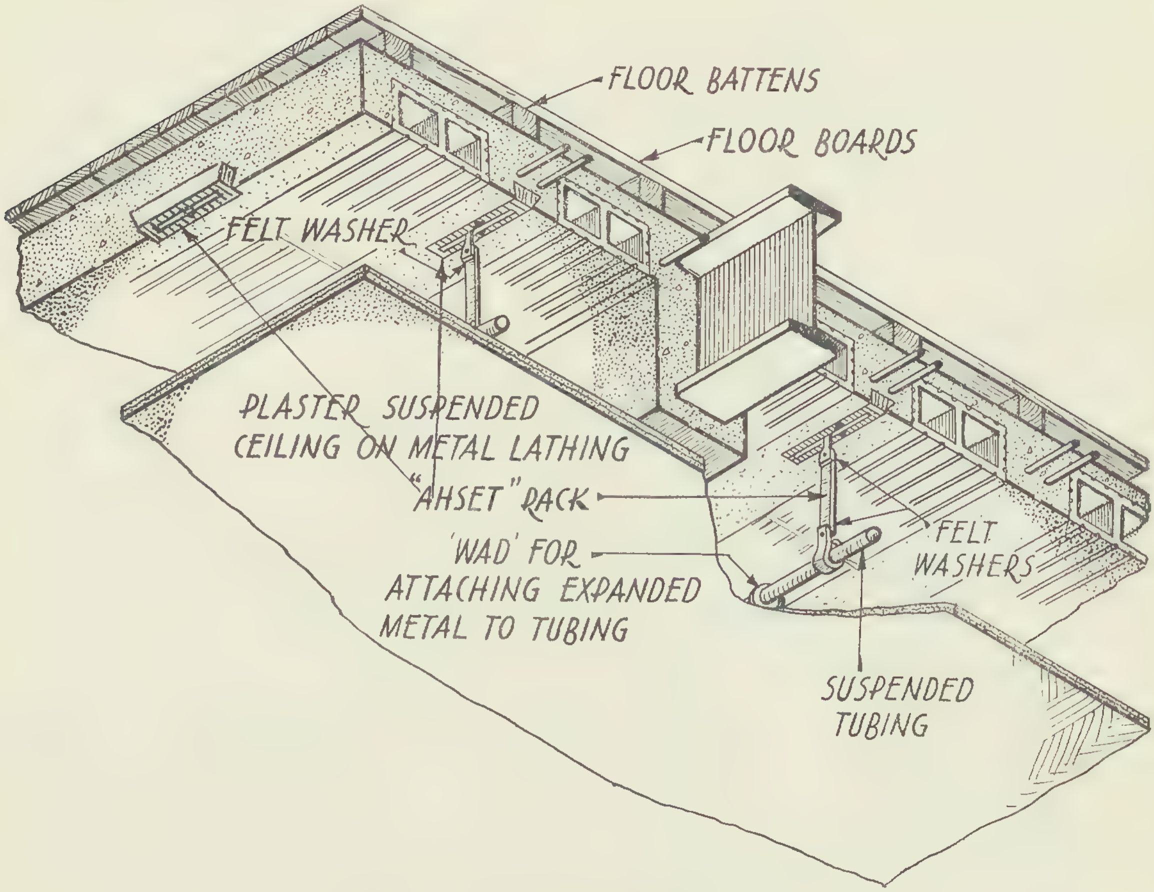

Fig. 142. Insulating Suspended Ceilings

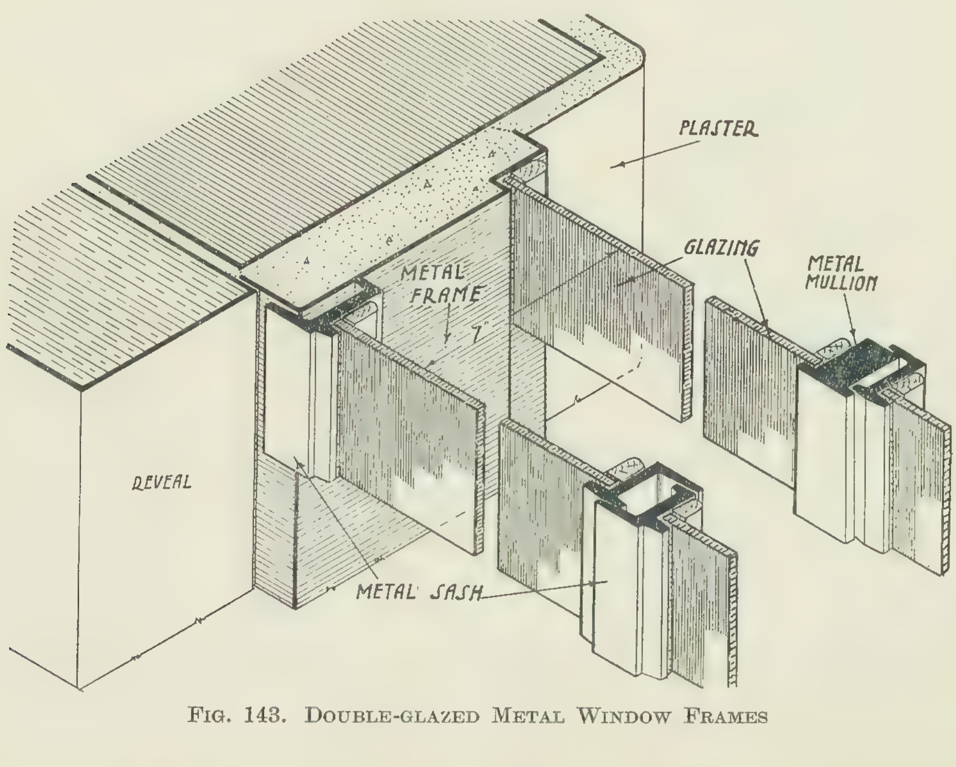

Fig. 143. Double-glazed Metal Window Frames

When fixed double windows are used, other provision must be made for ventilating purposes. This may be accomplished by providing air-bricks or metal vent boxes in the external walls. The inclusion of these apertures will permit sound waves to enter the room, and the insulation of the windows and walls rendered more or less ineffective.

If ventilation apertures are desired, they should be provided with baffle plates lined with sound-absorbent material, and designed so that the plates may be adjusted to the requirements of the inmates of the room.

CHAPTER X

HEATING AND VENTILATING OF BUILDINGS

It is not intended to deal with the principles of heating and ventilation, but to explain what construction is necessary for the housing of the apparatus involved in modern systems connected with the two problems. The construction adopted in modern buildings has caused many changes in the method of warming and ventilating the interior of buildings.

One of the most important is due to the almost entire omission of fire-place and chimney flues. This is typical of modern framed structures. For the heating of domestic buildings, fire-places and chimney flues are generally provided, and although this old-time method can claim many advantages over centralized systems of heating, there is no doubt that its continuance is due to custom and expediency rather than the derivation of benefit.

Fire-places and chimney flues assist in keeping the interior of domestic buildings ventilated. For commercial and public buildings their existence for this purpose is not warranted, as the installation of a ventilating system entails the incorporation of ducts.

Heating Systems. The selection of a heating system for a building entails a decision between

(*a*) *Direct heating*, which is obtained by placing radiators in rooms, or concealing them under the surfaces of walls, panels, and ceilings; and

(*b*) *Indirect heating*, which is the conveyance of warm air into rooms, mechanically or otherwise, through a system of ducts.

The latter method introduces the problem of ventilation of buildings; therefore the installation of the ventilating system should be considered at the time and in unison with the heating system.

The medium for the transmission of heat into a building may be hot water, steam, or electricity.

Transmission of Heat. Heat is transmitted by (1) conduction; (2) convection; (3) radiation.

Conduction is the transmission of heat from particle to particle of the same substance.

Convection is the transmission of heat by the circulation of a fluid or gas, over a surface of a colder or warmer body.

Radiation is the transmission of heat through the medium of the ether, and operates in straight lines until it is intercepted or absorbed by some body.

One of the difficulties in heating the interior of modern buildings arises through the loss of heat in its transmission by building materials, and infiltration. To overcome this difficulty and so reduce the loss of heat, it is necessary to give much attention to the use of suitable materials and methods of construction. The use of the ordinary forms of vertical radiators which were usually placed under windows or against external walls is gradually disappearing. These are giving place to some form of radiation in which the heated surfaces are concealed behind panels in walls or ceilings.

Panel Heating. For heating commercial buildings, etc., it is usual to install panel heating, which is a system of low temperature direct radiation.

Low Pressure Hot Water Systems. Large areas of walls, piers, and ceilings are heated by means of small diameter pipes through which hot water circulates at a temperature ranging from 70° to 135° F. The heating pipes or coils are secreted below the surface of ceiling or wall, or placed behind a panel in the wall surface.

Also the pipes or coils are attached to the underside of the concrete floor slabs, or concreted in the lower part of the floor slab, or suspended from floor

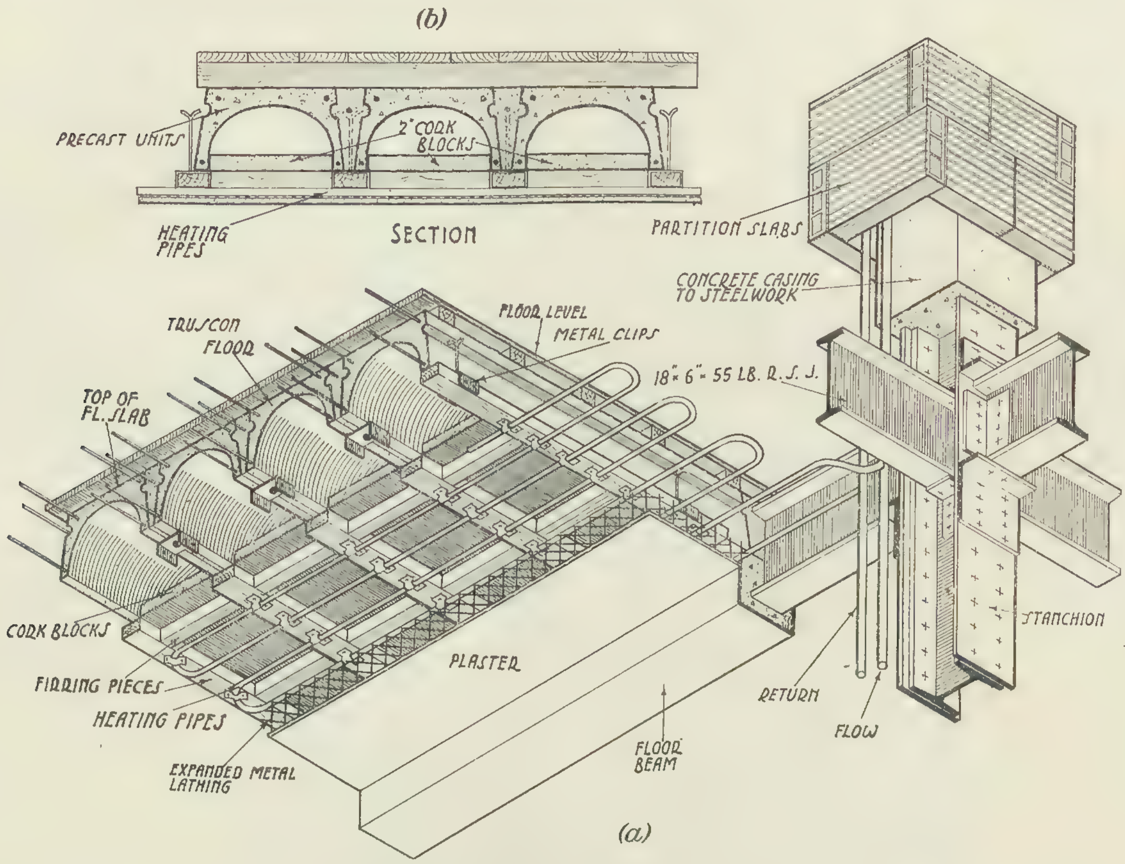

Fig. 144. Panel Heating Coil Attached to Underside of Precast Concrete Floor Units

(a) Sketch showing arrangement of heating coils.
(b) Section through floor.

slabs; and then covered by plaster or the material which is to form the ceiling surface.

The heating of the surface depends almost entirely on radiant heat.

Figs. 43, 144 (a), and 144 (b), show an arrangement for secreting the heating coils in a ceiling. They are shown fastened to a timber framing which is attached to the underside of a precast Truscon floor. The floor slab is insulated by a layer of cork slabs placed above the framing. The inclusion of this layer of cork causes the hot air to be directed downwards upon the occupants of the room below.

The vertical flow and return pipes are conveniently concealed in a duct. This is made by enclosing the concrete about the steel stanchion with partition blocks.

The ceiling is formed on a backing of expanded metal which is placed so as to be in contact with the heating coils.

The embedded system of panel heating consists of a similar arrangement of piping secreted in the lower part of the floor slab. Fig. 139 illustrates this method.

Sometimes the pipes are laid on the wood shuttering and then the floor slab is formed. In other instances the pipes are placed in position before the wood shuttering is erected. This method of secreting the pipes is not practicable when suspended ceilings are required for housing ventilation ducts since the ceiling surface must be in direct contact with the heated pipes and the underside of the floor slab. A suitable method when a suspended ceiling is desired is shown in Fig. 145.

The heating coils are suspended or held in position and then embedded in a thin slab of concrete cast *in situ*, and of sufficient thickness to cover the pipes.

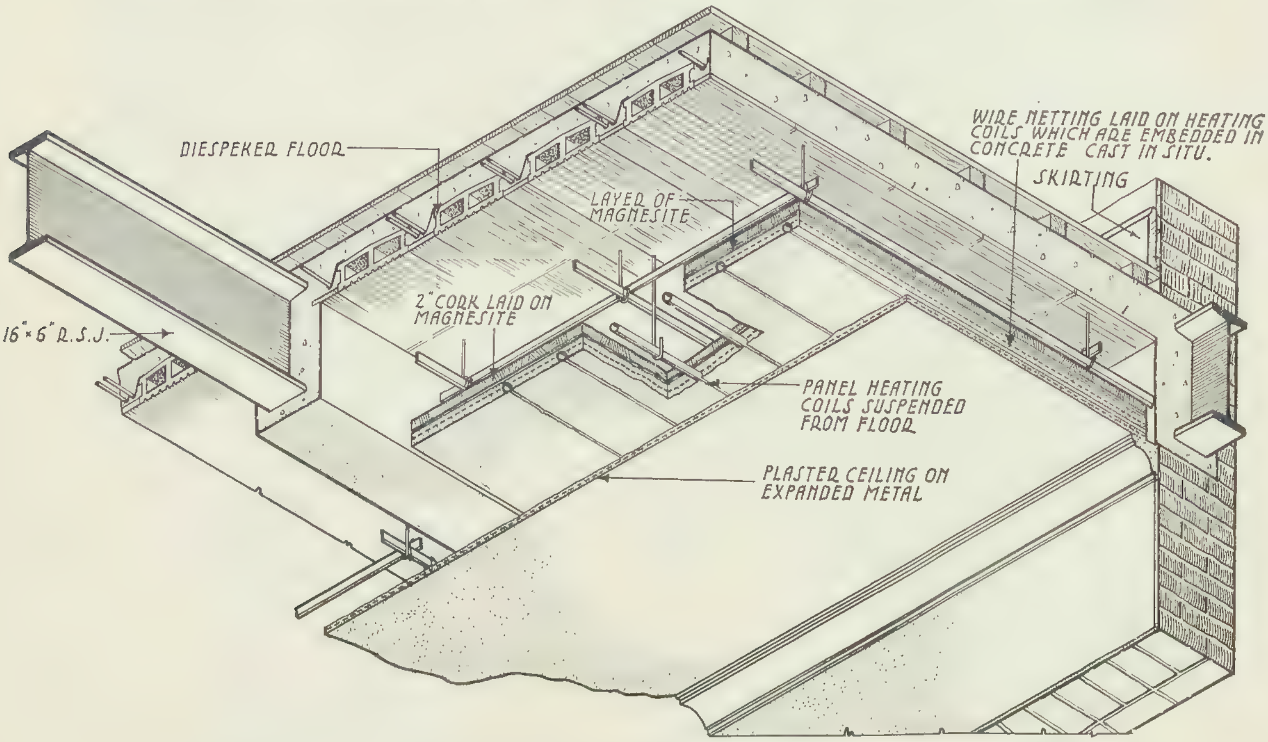

FIG. 145. PANEL HEATING COILS EMBEDDED IN SUSPENDED CEILINGS

The underside of the heating panel is covered with expanded metal and plastered so as to form the finished ceiling and heating surface. Wire netting is embedded in the concrete slab for binding purposes. A 2 in. layer of cork which is placed on top of the concrete slab forms the insulating layer and is bedded upon a layer of magnesite.

This building-up of the suspended heating panel insulates it from the floor and ensures the maximum amount of radiant heat in a downward direction.

The advantage claimed for panel heating is that the fabric of the building absorbs the heat. The materials composing the fabric are slow in conductivity; therefore in a building which has been thoroughly heated by these means some time will elapse before the interior of the building has cooled.

Panel heating systems should be thermostatically controlled so as to prevent any likelihood of the temperature being raised beyond the limit stated. A higher temperature will cause damage to the materials in which the coils are embedded or surrounded by varying the coefficient of expansion between the two materials.

Expansion of the coils due to a rise in temperature is one of the chief difficulties connected with the embedded system of panel heating, and unless care is exercised in the construction and suitable materials chosen for the finishing of the ceiling or wall, unsightly cracks will occur throughout the surface.

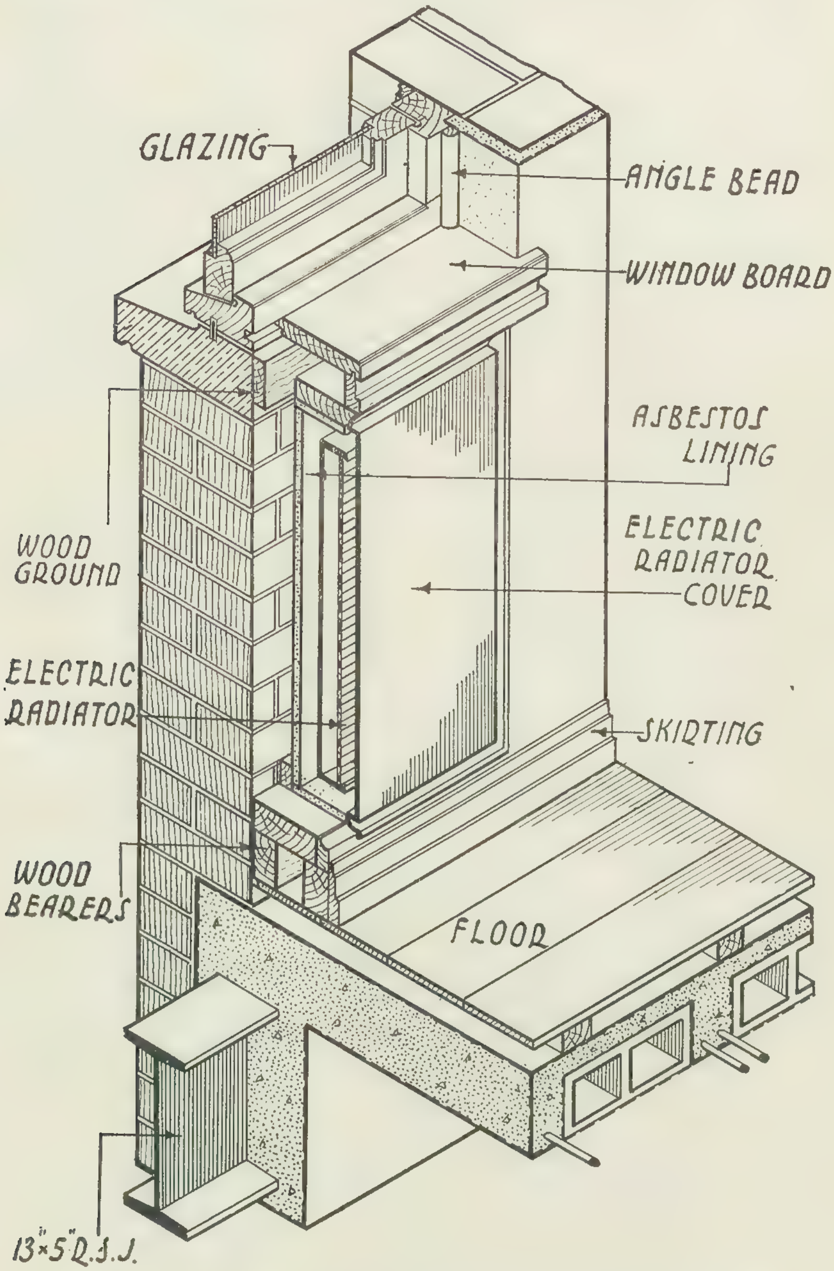

Fig. 146. Arrangement for Electric Panel Heating Units

When heating coils are embedded in the concrete floor slab the provision of an efficient key for securing the plaster is a very important item. Hacking the under surface of the floor slab to form a key should not be permitted, as damage to the pipes is likely to occur. A key should be formed when the floor is being constructed. This may be done by using one of the patent keying devices which can be obtained.

As an alternative method to the above, the plaster ceiling may be secured to a backing of expanded metal attached to the underside of the floor slab.

Particular attention should be given to the selection of the most suitable materials with which to form the heated surfaces. Lime plaster bound together with scrim appears to be among the best of them. It is coarse in texture. Air cracks will not be so apparent, and the scrim will assist in reducing the amount of crazing of the surface.

To meet the modern demand for concealed heating systems, radiators of various forms have been designed for secretion behind wall panels rather than in the ceiling. These units are usually fitted in recesses under window openings, or in any convenient position in the walling surface. The advantage claimed for this method of panel heating is that the heated coils are accessible, and are not subject to trouble from corrosion to the same extent as coils embedded in the structural floor.

As the heat which is given off by these units is more or less radiant heat, and the pipes are not embedded, the temperature may be raised above that already advocated for low temperature heating systems. In any case a higher temperature is necessary because under these conditions the heated surface is relatively smaller in area than with the embedded system.

Electric Panel Heating Systems. Electricity is being used for low temperature panel heating systems.

Except for the omission of the boiler and the inclusion of direct thermostatic control, the methods adopted are similar to those incorporated in low temperature hot-water panel systems.

Electrical elements are used in place of the pipe coils through which the hot water travels.

The electric elements are embedded in an insulated plastic material and attached to slabs of cork. These in turn are secured to the underside of floor slabs or against wall surfaces, and afterwards covered with a layer of plaster which forms the finished ceiling and wall surface.

The elements may be encased in a panel in the recess under window openings, and the heating surfaces may be a slab of marble or a sheet of metal as shown in Fig. 146. The advantage claimed for electric panel heating is that there is a considerable saving in installation costs. Several panel units can be used in one area of a wall or ceiling surface, or as a skirting or dado around a room; also the units can be switched on or off independently as the temperature of the room demands.

Ventilation of Buildings

Ventilation has for its object the removal of vitiated air and its replacement by clean air, volume for volume. The principal feature of a satisfactory system of ventilation is the maintenance of a right condition in respect of humidity, air movement, absence of dust particles, and correct air temperature.

These conditions are necessary so that any given temperature and humidity in a building may be endured at any period of the year without having recourse to open windows. A chimney flue with a fire at its base is a powerful means of ventilation, but the absence of chimney flues in modern building construction calls for some method of artificial ventilation.

Ventilation is generally considered of more importance than heating, but wherever they are both required they should be considered together.

The Combined System. Even when a separate system of direct heating is desired, it is often preferable to install a combined system of heating and ventilating, apart from the direct system just mentioned.

The air for heating and ventilating should be drawn into the building by means of a fan situated in a chamber conveniently placed for air intake. This chamber is sometimes situated above the roof surface, but more frequently in the lower part of a building and adjacent to an open area or at the foot of a special intake shaft. In this chamber the air should be washed, filtered, heated, and passed through a de-humidifying plant so that during the winter months it is cleaned and warmed and brought to the desired humidity before it is passed into the building.

Methods of Ventilation. The methods by which buildings are ventilated may be divided very broadly into three classes—

(1) By forcing the air into a building and allowing it to find its way out.

(2) By withdrawing the vitiated air from a building and providing special inlets for the admission of fresh air.

(3) By a balanced system, in which the air is both forced in and mechanically withdrawn.

To force the air into a building by means of fans connected to external walls is not a suitable method of ventilation; because direct air currents are developed which in turn create draughts.

A similar disadvantage exists when the air is mechanically withdrawn. The provision of numerous inlets which are necessarily situated in various parts of a room will only multiply the number of draught passages.

THE BALANCED SYSTEM. If the rooms are to be used for the gathering of a large number of people the most effective system of ventilation is the balanced system. In this the air is mechanically forced into the room through one system of ducts and mechanically withdrawn by another.

This form of ventilation is usually combined with an indirect heating system which tends to produce air movements at low pressure.

The air is generally forced into the building at a slightly higher pressure than that used for its extraction.

Provision for Housing Ducts. The general use of the combined system of heating and ventilating has been the cause of many changes in methods of building construction, since it is requisite that the air should be forced and extracted through a complete system of ducts. These are usually concealed in the walls and under floors of the building.

The main vertical ducts are usually concealed in the thickness of piers, etc., as in Figs. 147 (*a*) and 147 (*b*). The construction shown in the sketch is typical of the arrangement of the vertical ducts and their connexion with the horizontal branch ducts which are suspended from the floors and concealed in the space between the underside of the floors and above suspended ceilings.

These ducts are usually made from galvanized sheet iron. Asbestos cement and specially prepared reinforced concrete ducts are also coming into use for some purposes. The reinforced concrete ducts are very suitable for embodiment in piers, walls, etc.

Fig. 148 also illustrates how horizontal ventilation ducts may be housed in the space between the floor slabs and suspended ceilings.

The provision of suspended ceilings in modern building construction to house

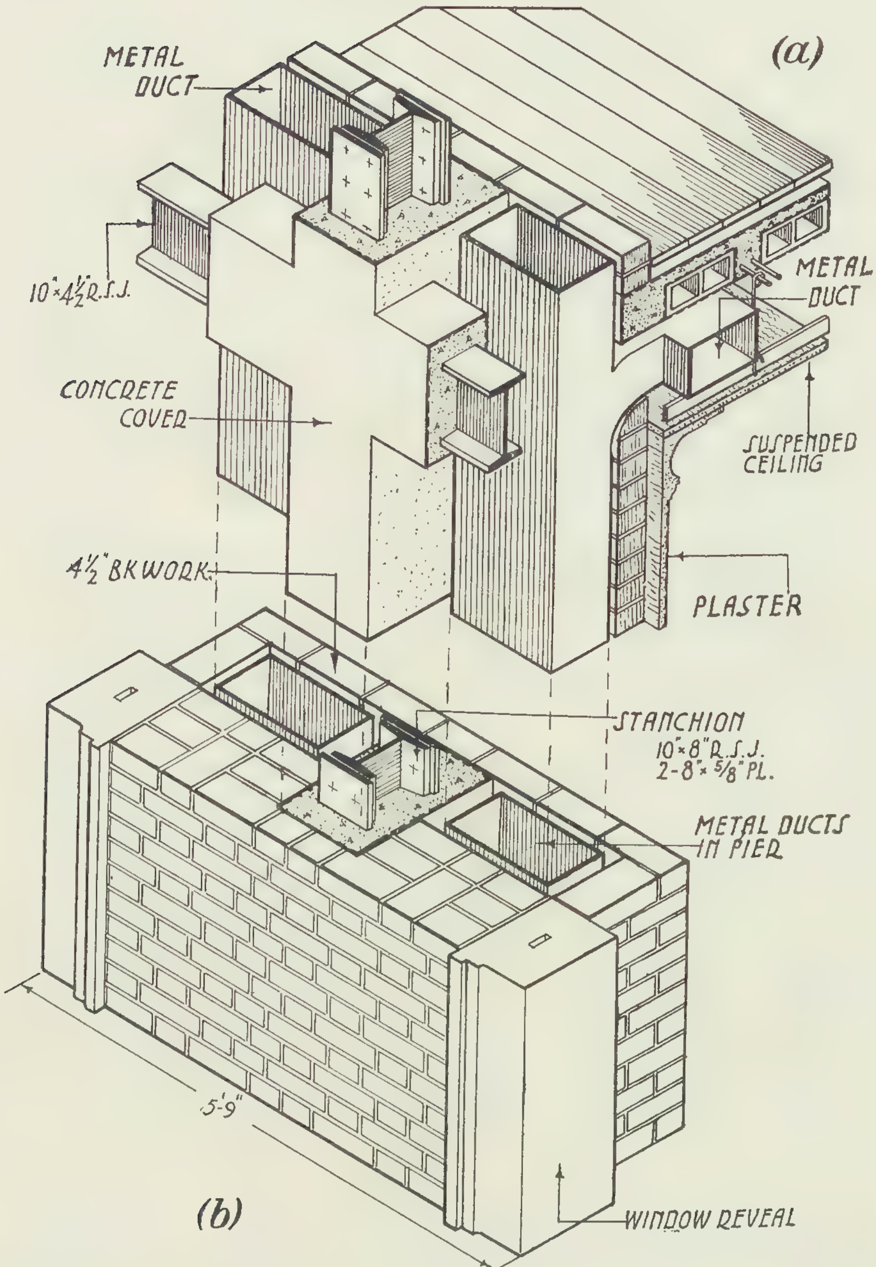

FIG. 147. PROVISION FOR HOUSING VENTILATION DUCTS IN WALLS AND UNDER FLOORS

(*a*) Arrangement of ducts under floor.
(*b*) Ventilation duct in pier.

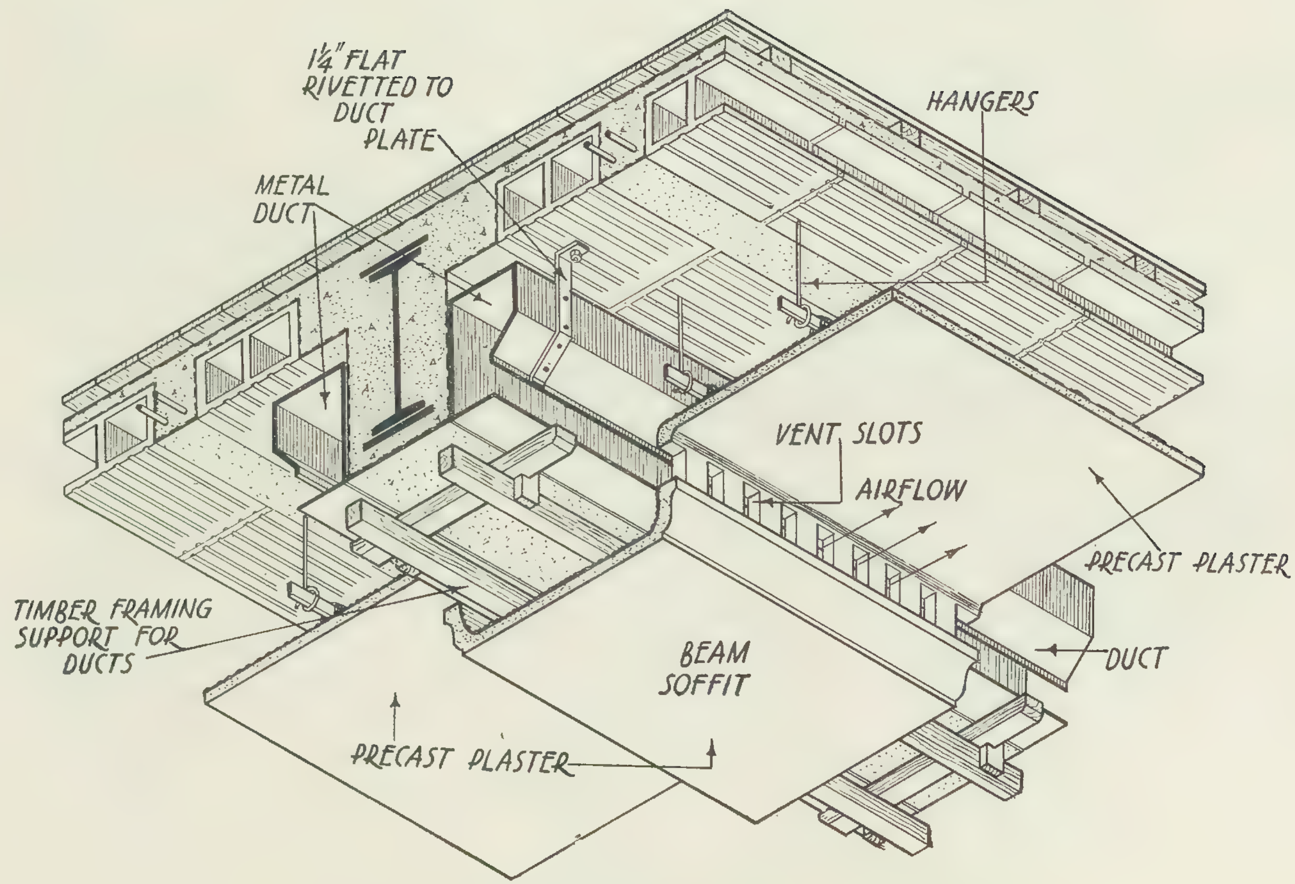

Fig. 148. Housing Ventilating Ducts under Floor Slabs

these services tends to reduce the height of the rooms, or, on the other hand, to increase the height of the buildings. Their inclusion has, however, become a necessity through the development of heating and ventilating trunking systems.

Air distributing ducts should be placed so as to reach the points of air delivery

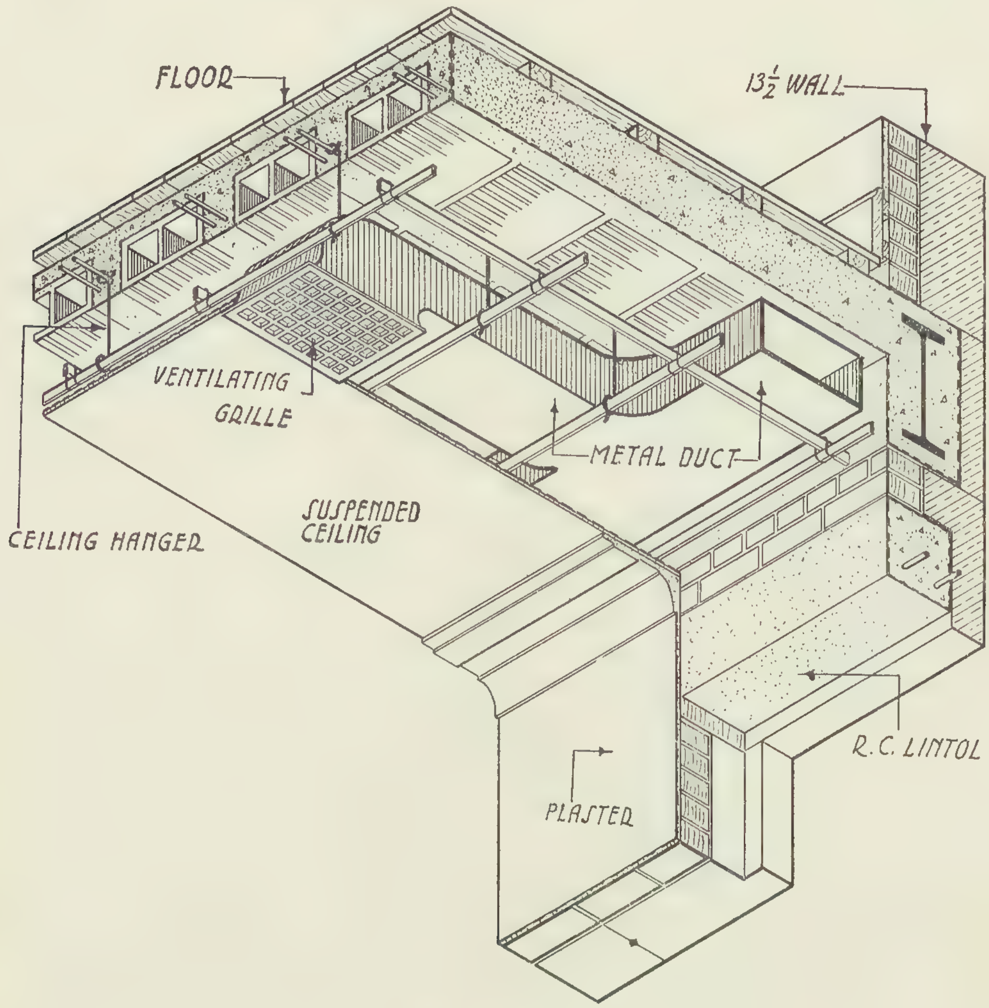

FIG. 149. HOUSING VENTILATING DUCTS UNDER FLOOR SLABS

as directly as possible and connected direct to grills, whether they are placed in the walls or in the ceilings. (See Fig. 149.)

In many instances, especially in buildings such as cinemas, theatres, etc., the heating and ventilating system could be improved by the inclusion of a combined refrigerating and de-humidiating plant so that the temperature might be more closely controlled.

The warm clean air is admitted at or about floor level and extracted at or about ceiling level.

In the case of cinemas, halls, etc., the best situation for the extraction gratings is under the seats. Fig. 150 is a sketch at floor level showing the construction and the arrangement of the ducts in the floor and wall of such a building.

The extract gratings are situated under the seats and connected to the main extract duct.

The inlet gratings could be situated near the ceiling level, as in Fig. 148, or they may be incorporated as part of the suspended ceiling surface as in Fig. 149.

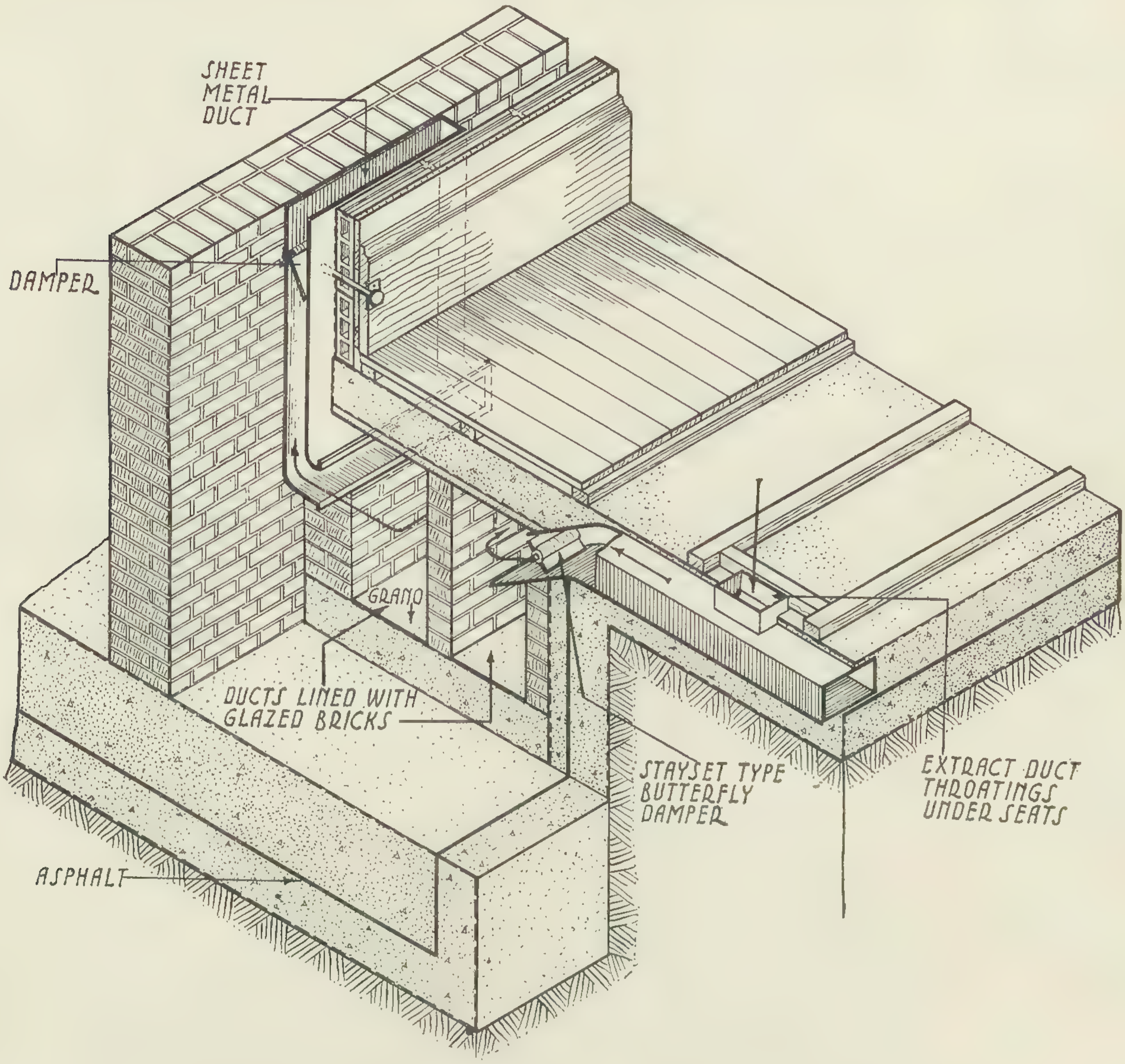

Fig. 150. Construction of Ventilation Ducts in Floors and Walls

In Fig. 150 it will be noticed that the dampers are arranged so that the system can be regulated by the occupants of the room or hall.

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